MACHINERY.

January, 1905.

HEAVY WORK OF THE PORT RICHMOND IRON WORKS.

THE works of the I. P. Morris Co., Philadelphia, known as the Port Richmond Iron Works, date their origin as far back as 1828. Their history is almost coincident with that of the development of the iron and steel industry of this country, and they have carried through some of the most important engineering work in the way of pumping engines, turbines, blowing engines, centrifugal pumping machinery, etc., that has been done. Among these are included the Boston sewage pumping engine, and the Louisville Pumping Engine No. 3, both designed by E. D. Leavitt. The former of these is the largest in the world and the latter has proved itself the most economical of its type. Other notable installations are the 15,000 H. P. engine for operating the forging presses at the Bethlehem Steel Co.'s works, which have been illustrated in MACHINERY, and much of the massive machinery installed at the Calumet and Hecla Mines, most of which was designed by E. D. Leavitt. As a matter of historic interest, it may also be stated that they have built engines for certain of the monitors used in the Civil War, under the patents of Ericsson; and the old Cornish engines for the Buffalo water works which they constructed were among the first of the kind in the country.

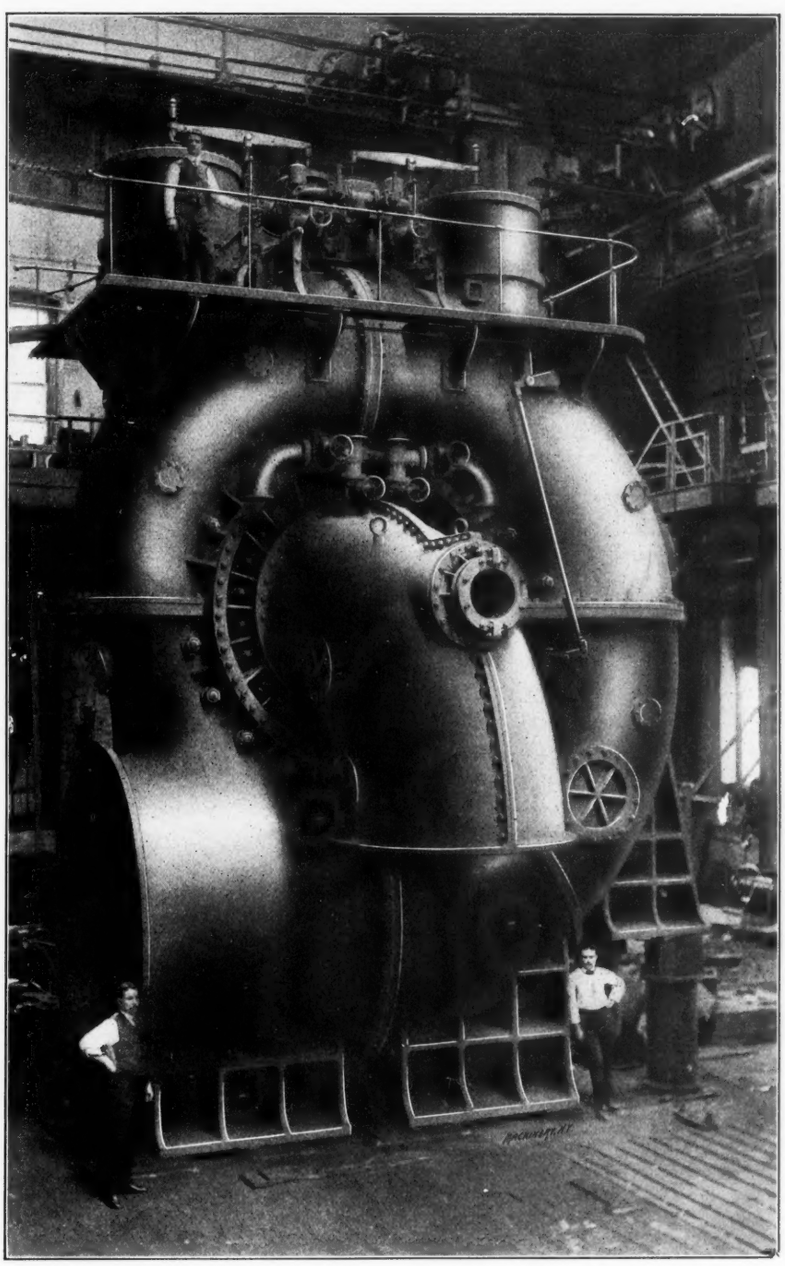

Fig. 1. 10,500 H. P. Turbine for the Shawinigan Water and Power Co., P. Q., Canada.

In a bulletin recently issued by the I. P. Morris Co. is given an interesting account of some of the more recent engineering construction carried through by them, and for the account which follows we are indebted to the descriptive matter contained in this bulletin.

Fig. 3 is a view showing the interior of the south bay of the Port Richmond Works, with some of the large turbines of 10,000 H. P. capacity for the Canadian Niagara Falls Power Co. in process of construction. These turbines operate under a head of 145 feet at 250 revolutions per minute, and were built from designs of Escher, Wyss & Co., Zurich, Switzerland. The station will eventually have a capacity of 110,000 H.P.

When the Niagara Falls power plant was projected the I. P. Morris Co. secured the contract to build the turbines—the largest up to that time. The first installation consisted of 10 units of 5,000 H. P. each, and these were followed by 11 larger turbines of 5,500 H. P. for the second plant. An illustration from a photograph of one of the 5,000 H. P. units is shown in Fig. 2 with a portion of the shaft leading to the generator above, and of the elbow connecting the wheel case with the penstock and supporting the latter. It is estimated that the energy produced by the falls of Niagara is the equivalent of more than 7,000,000 H. P., and from this immense amount some 75,000 H. P. is now utilized by this plant, situated about a mile and a quarter up the river on the American side. Here a surface canal 250 feet wide and 12 feet deep leads the water to the power house. The solid masonry walls of the canal are pierced by twenty-one inlets through which the water enters the penstocks in the wheel pits, which are huge excavations 178 feet deep by 18 feet wide and 400 feet long running parallel to the canal, one on either side, about 75 feet away. Penstocks of steel plate 7½ feet in diameter bring the water to the turbines near the bottom of the pit, and these drive the generators vertically over them through shafts 160 feet long or more. The discharge water from the turbines is conveyed from the bottom of the wheel

pits to the main tunnel, and thence into the lower Niagara River. The electric system used is the Tesla polyphase alternating current type, in this case generating a 2-phase, 25 frequency, 2,200-volt current. To consumers within a radius of one or two miles the current is sent, at the voltage generated, over lead-covered cables laid underground in a large conduit and transformed at the user's plant to the required voltage. For the long-distance transmission circuits, to Buffalo and in some instances to points 39 miles away, it passes through similar cables to the transformer house, where it is "stepped-up" to 22,000 volts, at which potential it is carried on overhead wires to sub-stations at the other end, where "step-down" transformers reduce the voltage to suit the local demands. The plant is so constructed that the available H. P. is 110,000, and this development may be made without a perceptible diminution of the flow over the falls.

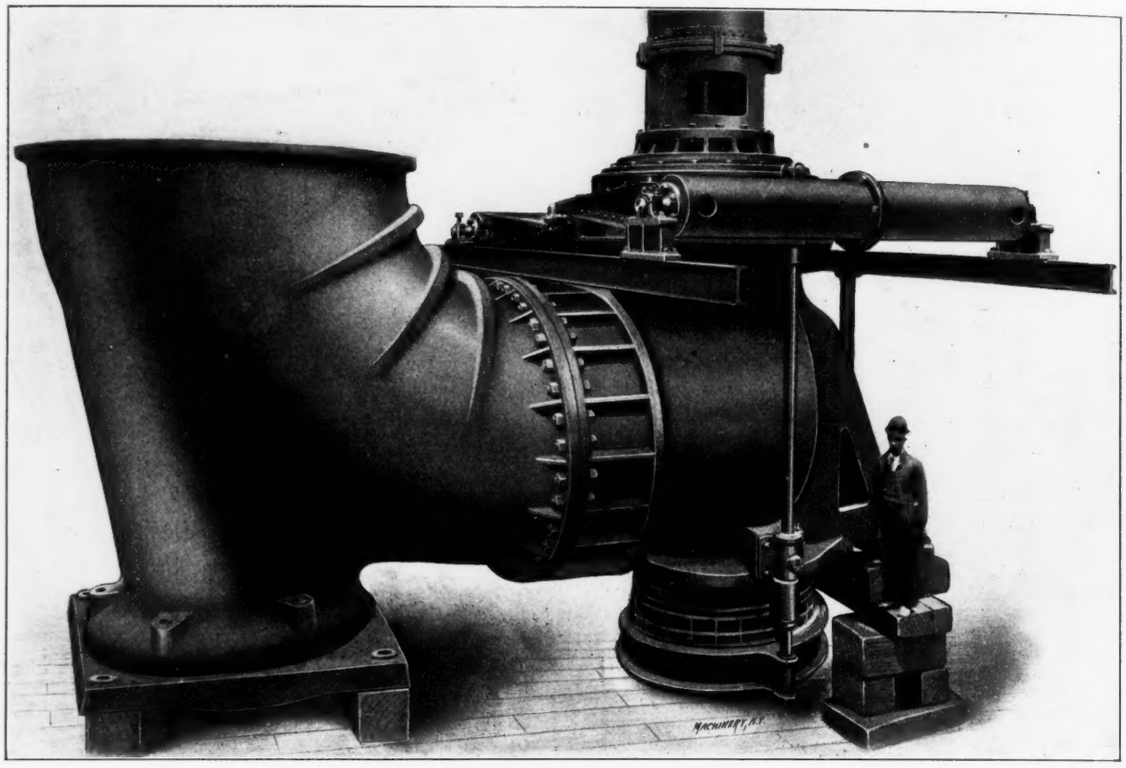

Fig. 2. One of the 5,000 H. P. Turbines in Power House No. 1 of the Niagara Falls Power Co. Shows Elbow connecting Wheel Case with Penstock.

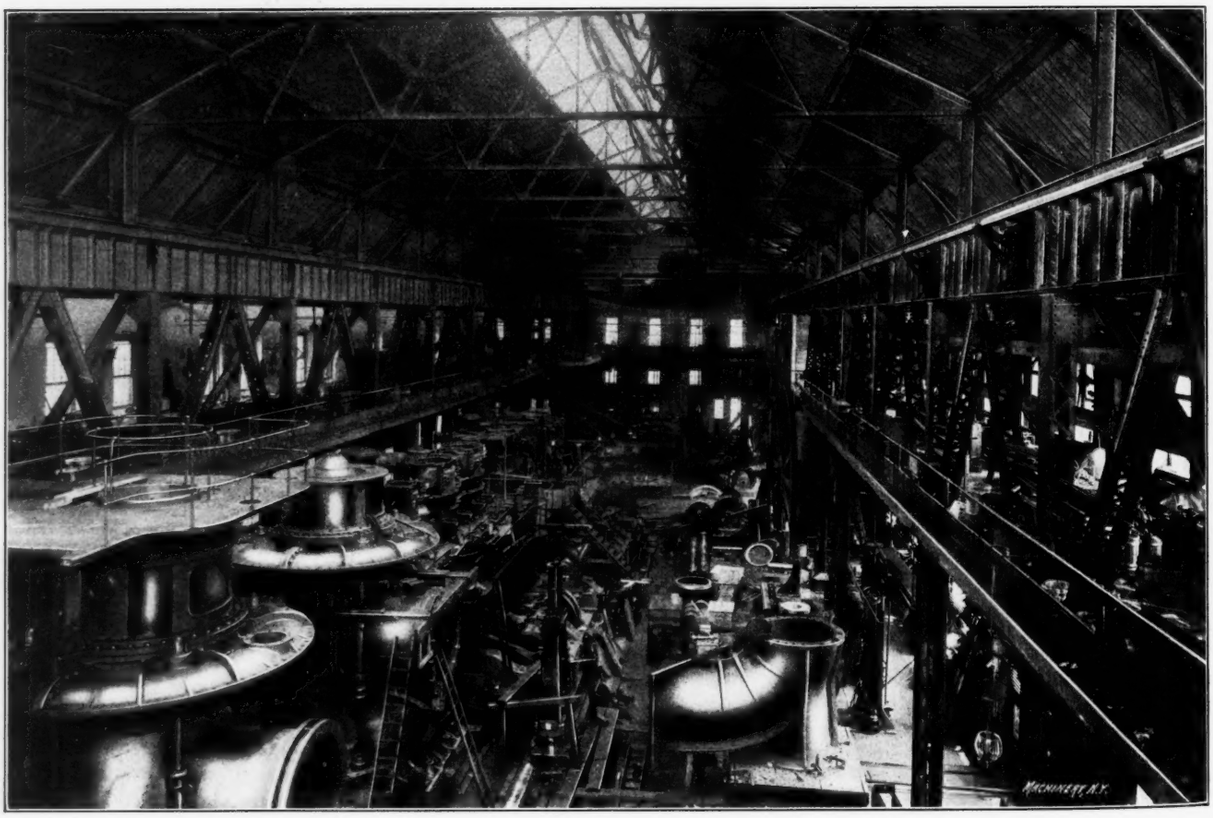

Fig. 3. South Bay of Machine Shop, I. P. Morris Co., Philadelphia; showing 10,000 H. P. Turbines in Process of Construction.

In Fig. 1 is a view of a wheel of 10,500 H. P. now being installed by the I. P. Morris Co. at the plant of the Shawinigan Water & Power Co., Shawinigan Falls, province of Quebec, Canada. This is believed to be the largest water power unit ever constructed, and is one of four located at this plant, three of which were built by the Port Richmond Works. The plant is 84 miles northeast of Montreal, and is an ideal location for the generation of electricity by water power. Not only is there available a high head, a large quantity of water and a nearly constant flow, but the river widens out to a "lake" both above and below the falls and makes a right angle bend between the two lakes, thus bringing the upper and lower water levels within a short distance of each other and providing a convenient and economical location for the plant on the slope between the lakes. The company has purchased property on both sides of the river for factory sites and operatives' houses, for it is hoped that various industries will be attracted by the cheap water power. Already the wilderness of five years ago is a substantial city of 5,000 inhabitants, and this development has been accomplished without marring the natural beauty and surroundings of Shawinigan Falls. The power capacity of the stream at this point is estimated at 125,000 H. P., and the plant is so built that an ultimate development of 100,000 H. P. is possible when such an amount of power can be profitably disposed of. From the south end of the upper lake a canal 20 feet deep and 1,000 feet long was excavated through rock to a point where, in a distance of 500 feet, the ground makes a drop of 140 feet. At this point the canal was closed by a concrete wall containing outlets for six penstocks, each 9 feet in diameter. Three penstocks 450 feet in length carry water to a like number of turbine wheels in the power house, and two other somewhat longer penstocks lead to the power house of the Northern Aluminum Co., which purchases its power in the hydraulic form, using its own turbines and generators. Each of the three penstocks supplying the Shawinigan Falls Power House furnishes water to a 6,000 H. P. horizontal-shaft turbine direct-connected to a 3,750 K. W. revolving field generator giving a quarter phase, 2,200-volt, 30-cycle current. The new wheel now being installed is of the horizontal shaft inflow type, with spiral casing and draft tube on each side through which the water discharges outward from the center. The spiral casing permits the penstock to be received below the floor of the power house, thus leaving room for oil switches under the switchboard gallery. The design includes a hydraulic hand gear mechanism and other novel features. The wheel is designed to operate under a normal head of 135 feet. Of the present output of the plant about 10,000 H. P. is transmitted over long-distance lines 84 miles to Montreal and there used for street railways, electric lighting and general power purposes. The current is stepped up at Shawinigan to 50,000 volts, three phase, and carried over three cables to Montreal, where it is stepped down, with a loss of about 18 per cent in transmission. A second line to Montreal to carry another 10,000 H. P. is now being built, and a third is in contemplation.

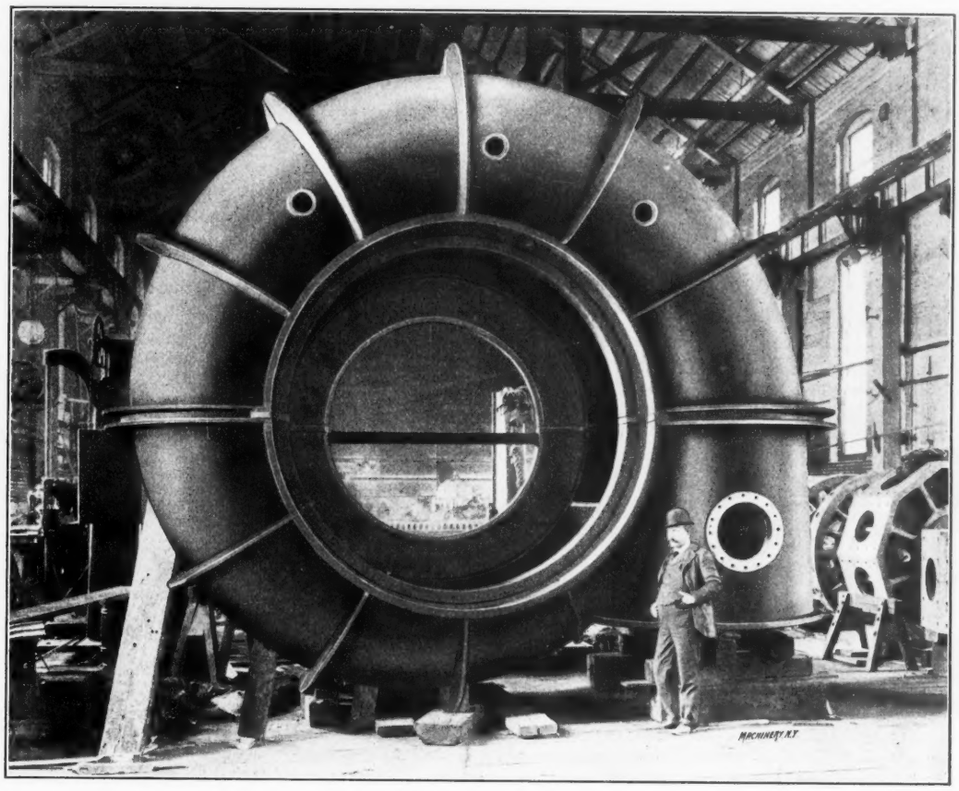

Fig. 4. Volute Casing of Vertical Shaft Centrifugal Pump for the Metairie Pumping Station, New Orleans, La. Diameter of Discharge, six feet. Said to be the Largest Pump made.

Another plant in which the I. P. Morris Co. has installed machinery is the Niagara Falls Hydraulic Power & Mfg. Co., located on the bluff above the lower Niagara River. While the turbines in this plant are only about one-fourth the size of the one just mentioned, they are still very large and give a high degree of efficiency. The water is supplied by a surface canal running from the upper river through the city, a distance of 4,400 feet, to a reservoir on the bluff, whence it flows to the various mills and is discharged by short tunnels through the bluff into the river below. A new power house has now been built at the foot of the cliff where the entire available head of water can be utilized with a consequent increase of power; moreover in this way the need for long transmission shafting is avoided. The water is led from the canal to the wheels through huge penstocks which pass down over the bluff. The total present output of this plant is about 35,000 H. P.

Two large turbines now in course of construction at the Port Richmond Works are destined for the plant of the Canadian Niagara Power Co., which is now erecting its third power house on the Canadian side of the upper Niagara River. Its hydraulic features will be similar to those of the Niagara Falls Co., with which it is to operate in parallel. The units will, however, be of 10,000 H. P. capacity, and the generators will be wound for 11,000 volts, three-phase. The turbines are of the Francis inflow type with draft tubes on either side, and they share with the 10,500 H. P. unit built for the Shawinigan Co. the distinction of being the largest turbines constructed up to the present time. Another plant equipped by the I. P. Morris Co. is the Trenton Falls Plant of the Utica Gas & Electric Co. The power house is fitted up with four vertical shaft turbine units of 2,100 H. P. capacity direct-connected to generators. This hydraulic plant gives very satisfactory service, inasmuch as it is almost constantly run at its full capacity, and has established the record of a load factor of 98 per cent of the full output.

Another branch of hydraulic machinery to which the I. P. Morris Co. have devoted much care and attention is the construction of centrifugal pumps, and their most notable work in this line has been in connection with the pumping stations of the New Orleans Drainage Commission. At the Metairie Pumping Station, New Orleans, they recently installed

a vertical shaft centrifugal pump, the volute casing of which is shown in Fig. 4. This pump has a diameter of discharge of 6 feet, a diameter of impeller of 9 feet 4 inches, and a capacity of 320 feet per second at the lift of 10 feet, with an efficiency of 74 per cent. This is believed to be the greatest quantity of water ever discharged by a single pump. This pump is driven by a direct-connected 500 H. P. alternating current motor. Three centrifugal pumps of the horizontal shaft type have been installed in St. Bernard Pumping Station No. 3, also at New Orleans. These are all driven by direct-connected motors, and consist of one "constant service" pump having a capacity of 50 cubic feet per second with a lift of 12 feet, and two "special service" pumps lifting 8 feet with a capacity of 250 feet per second. Each of the larger pumps has a discharge of 6 feet diameter at the pump, enlarged to 10 feet diameter at the discharge basin. To secure the highest possible efficiency, centrifugal pumps and turbines should be designed for the particular lift, capacity, and speed at which they are to operate, in order to better meet the conditions under which they will be required to work.

* * *

HIGH-PRESSURE OILING SYSTEM FOR HEAVILY LOADED BEARINGS.

Almost every one who has had anything to do with the operation of machinery, knows that "friction of rest" is much greater than "friction of motion," or, in other words, that more force is required to start a machine than to maintain the motion without load. The reason, of course, is that the journals sink down into their bearings and displace the oil films so that there is actual metallic contact, which causes them to drag heavily until the oil films are re-established. There is one serious feature of this well-known fact that, we believe, generally escapes attention, and that is the damage often done on heavily-loaded bearings during the starting period. A babbitt bearing may be badly scored at this time although it would give no trouble from heating afterward. In a recent issue the *Engineering Record* tells how this trouble is avoided in the plant of the Puget Sound Power Co. The main shaft of each 3,500 K. W. unit is of fluid-compressed nickel steel, with journals 16 inches in diameter, which are supported by babbitted surfaces 4 feet long. In addition to special oil grooves cut into both the top and bottom halves of the bearing, there is a special high-pressure oil groove not connected with any of the others. This is located vertically under the axis of the shaft, and connection is made to it by a flexible high-pressure oil pipe from a motor-driven oil pump supplying oil at 2,000 pounds per square inch. This system is only used in starting the wheels in order to avoid damaging the babbitt surface, as the rotating element weighs in excess of 98,000 pounds. A centrifugal oil circulating system is otherwise provided so that the bearings may be flooded with an additional amount of cool oil if heating occurs. In each bearing a pair of thermostats is connected in parallel in an electric circuit for indicating at the switchboard a dangerous temperature rise in any of the journal bearings.

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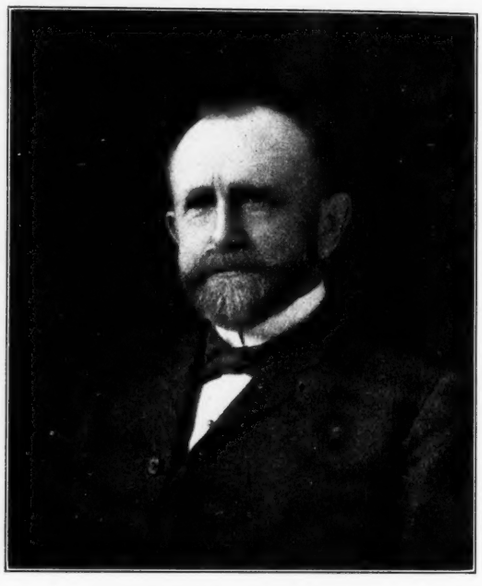
ANNUAL MEETING OF THE A. S. M. E.

The fiftieth meeting of the American Society of Mechanical Engineers was held in New York December 6 to December 9, as announced in the last number. The papers read were mostly of a highly technical character, there being fewer of a popular nature than has been the case for several years. The president's annual address on the evening of December 6 is abstracted in another part of this issue and following this Mr. C. W. Hunt addressed the society to present on behalf of an unnamed donor a portrait of Prof. John E. Sweet, one of the founders of the society. At the last session of the meeting Mr. James N. Dodge, of Philadelphia, also presented the society with a bronze bust of Capt. John Ericsson, made from a plaster bust of the great engineer, which was produced while Ericsson was alive.

The membership during the past year has increased largely, there now being 2,800. The expenses, however, exceed the income from dues of nearly $3 per member, and the dues, together with all other sources of income, are not sufficient to pay the running expenses of the society. The reports were given of the progress of the different committees on the Union Engineering Building and as a matter of course, much interest centered in this. Abstracts of some of the papers appear elsewhere in these columns and a brief sketch of the new president, Mr. John R. Freeman, Providence, R. I., together with his portrait, is published herewith.

The New President.

John R. Freeman, the newly-elected president of the American Society of Mechanical Engineers was born in 1855 in West Bridgeton, Maine. His early schooling was secured in West Bridgeton, and in later years he continued his studies at the public schools of Portland, Me., and Lawrence, Mass., finishing at the Massachusetts Institute of Technology, from which he was graduated in 1876, as civil engineer. His first position upon leaving the Institute was with the Lawrence Water Power Company, in whose employ he remained for a number of years, and where he acquired a vast knowledge of hydraulic engineering. He then took a position with the Factory Mutual Fire Insurance Companies as inspector, with a view to acquainting himself with the insurance business. He became particularly interested in fire protection engineering and, being made chief inspector and chief engineer, began a



John R. Freeman.

series of tests and investigations by which he was enabled to bring about many improvements and introduce many new methods. In 1896 he became president of the Manufacturers' Rhode Island & Mechanics' Mutual Fire Insurance Companies, whose business has increased greatly under his supervision. Recently he was made president and treasurer of three more insurance companies.

Mr. Freeman is also a member of the American Society and the Boston Society of Civil Engineers, of which latter society he was president in 1893. He has written several papers of great interest and value, among them one on the "Hydraulics of Fire Streams," and another on the "Nozzle as a Water Meter," for which he received the Norman medal awarded by the American Society of Civil Engineers.

* * *

Over 25 miles of one-inch steam pipe will be used in the hot blast heating and tempering coils to be installed by the American Blower Co. in the new Wanamaker store in Philadelphia. This pipe is being manufactured into one hundred and eleven heater sections, varying in capacity from 35,000 to 36,000 feet of heating surface. Twenty-eight ventilating fans will be used in the building, the largest having a housing of 220 inches and the smallest of 30 inches. The completed apparatus will make a 10-carload shipment. An "ABC" apparatus, of seven large fans and some 44,000 feet of 1-inch pipe, is also to be installed in the New York Wanamaker building.

A REVIEW OF STEAM TURBINE PATENTS.—3.

Seger, 1894.

Seger's turbine has been built and used to some extent abroad. His first patent specification, issued in 1903, shows an arrangement of wheels indicated in Fig. 36. Like Pilbrow and B. T. Babbitt, he seeks to secure a moderate speed of rotation by using two wheels turning in opposite directions.

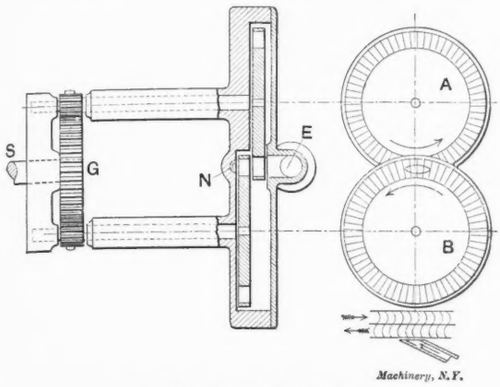


Fig. 36. Seger's First Patent.

The steam, in leaving the first wheel, impinges directly against the second without any intervening guide vanes. The turbine wheels, *A* and *B*, are on separate, parallel shafts, and at *G* are the gears by which the motion of the wheels is transmitted to the driving shaft, *S*. *N* is the nozzle through

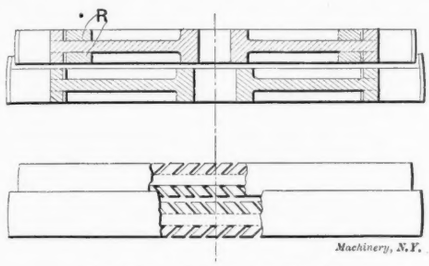


Fig. 37. Arrangement of Wheels.

which steam enters, and *E* the exhaust passage. His claim is for "a steam turbine in which the turbine wheels are placed in close proximity to each other, and are combined with one or more steam conduits discharging into the sides of said wheels in such a manner that the steam passes through the

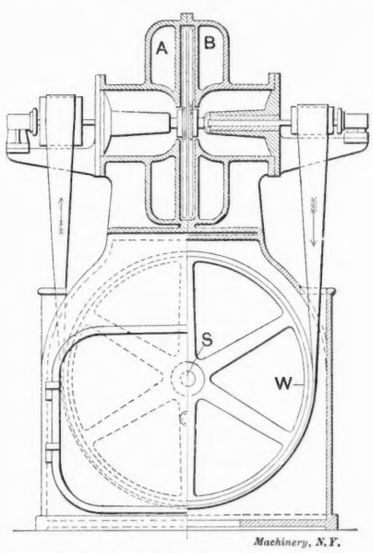


Fig. 38. Sectional Elevation of Seger Turbine.

wheels in the direction of their axes; and in which the shafts are arranged out of line with each other so that the wheels only partly overlap each other."

In his patent of 1894, Seger shows wheels arranged on the same axis, but rotating in opposite directions. A feature of the patent is the method for fastening the buckets in diagonal slots cut in the wheel rims. The lower view, Fig. 37, shows these slots, and in the upper view the rings, *R*, forced inside the rim, hold the projecting ends of the buckets in position. This construction will be evident from Fig. 39, where *A* is one of the buckets. At *B* the bucket is placed in the rim and at *CC* its projecting ends are bent over underneath the rim. In 1897 Seger issued an English patent upon an arrangement of his turbine by which the belted connection could be used for driving the low-speed shaft, Fig. 38, from which power is taken. Here *A* and *B* are the turbine wheels rotating in

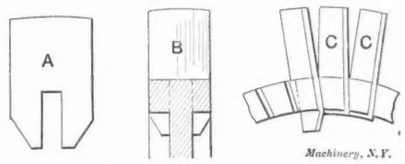


Fig. 39. Vanes of Seger Turbine.

opposite directions and attached to the ends of shafts which carry, at their outer ends, small belt pulleys. On the shaft, *S*, are two pulleys, *W*, of equal diameter, one of which is fast to the shaft, while the other is loose on the same shaft. The belt passing around these several pulleys, as indicated, transmits power from the turbine wheels to the main shaft.

McElroy, 1894.

This year marks the beginning of the important patents on turbine wheels of the Pelton type for use with an elastic fluid. Two patents were issued, one to J. F. McElroy in this country, and one in England to Professor A. Rateau. The arrangement of the nozzles and wheel of McElroy's invention is shown at *A* in the sectional view, Fig. 40. Nozzles with diverging mouthpieces are used. At *B* is a section of a bucket in a plane parallel with the shaft, together with an enlarged view of one of the nozzles. At *C* is a section through a bucket taken in the other direction. While an efficient type of bucket

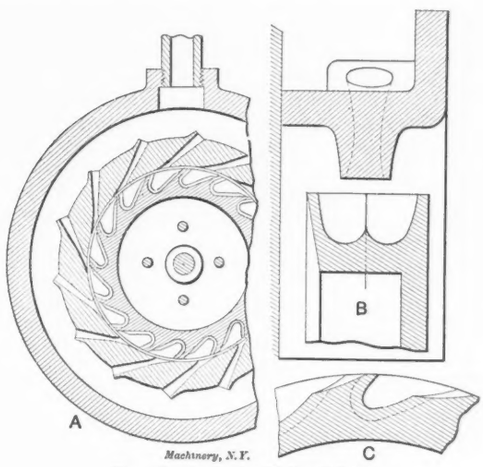


Fig. 40. An Early "Pelton" Type.

is shown, and McElroy's claims as to its shape are broad, taken by themselves, they are combined with certain other constructive features which limit the scope of the patent. What he claims is, first, a wheel comprising a solid metal ring having a series of inclined pockets therein, the pockets of each pair being divided by a tapering ridge, in combination with a circular steam ring having a circular series of nozzles; and secondly, pockets as above described, but with a flat inclined cut-away portion for each, as shown in the sketch.

Rateau, 1894.

Professor Rateau, of Paris, was one of the earliest to experiment with a steam turbine having a single wheel of the Pelton type. The essential features of his English patent on this are shown in Figs. 41 and 42, which represent the wheel vanes. He intended primarily to produce a reversible wheel and uses buckets projecting radially, with double concave surfaces, *A*, *B*, Fig. 41, which form a dividing wedge at the center, just as in the Pelton water wheel. For reversing the direction of rotation, he uses steam jets flowing in the oppo-

site direction and impinging against the backs of the blades. The backs are shaped as shown at *C*, with a single concave surface, instead of with the double curve, in order to avoid any obstruction to the steam when running in the normal direction. While the single curve is less efficient than the double curve, it answers the requirements for the brief periods during which the turbine has to be reversed.

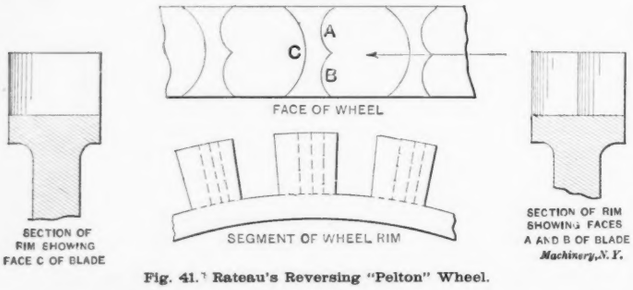


Fig. 41. Rateau's Reversing "Pelton" Wheel.

When the wheel is to be designed for forward motion only, Rateau presents the construction of Fig. 42. *A* and *B* are two concave vane surfaces and at the rear of each bucket an inclined groove, *C*, is cut, represented by the dotted line, *bp*, in the upper view. This allows the jets of steam to strike the buckets, one after the other, without interference from the successive buckets as they come into position. The sectional views at the right are taken on the line, *XY*, looking in each case, in the direction of the arrow drawn under each view.

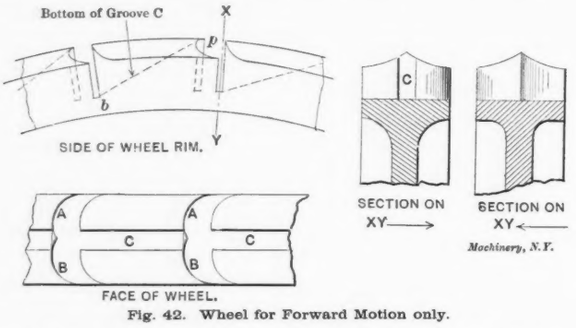


Fig. 42. Wheel for Forward Motion only.

While it is not introduced as a definite claim in this patent, Professor Rateau mentions that where the speed of the fluid is too great it may be necessary to arrange these turbines in series on the same or independent shafts, in which case the openings of the nozzles should all be designed to deliver the same relative quantity of fluid at the same moment. This he would accomplish by using distributing valves for supplying steam to the nozzles, and having these valves all operated positively from the same source so that they would act in unison.

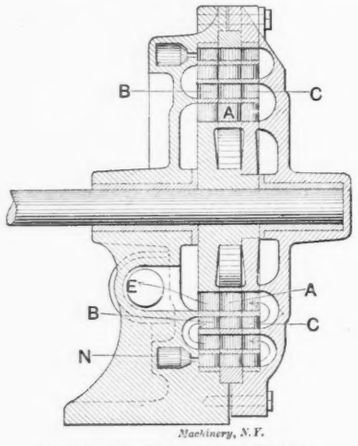


Fig. 43. Novel Compound Turbine.

Pyle, 1895.

The patent issued to G. C. Pyle for the turbine shown in Fig. 43 is a variation on the usual plan for compounding. *AA* is a stationary disk, containing the rows of guide vanes, and *BB* are rotating disks. Steam enters through the nozzle, *N*, and passes longitudinally through several vanes in the direction of the arrows, until finally it exhausts at *E*.

Parsons, 1895.

In the method of governing used on Parsons turbines, an oscillatory motion is given to the throttle valve by an eccentric driven by the turbine, and the extent of this movement is controlled by a governor. In the illustration, *A* is a double-seated valve attached to a valve stem, *B*, which is connected with a piston, *C*, working in a cylinder above the valve chamber. At *D* is a pilot valve for controlling the motion of the piston. The steam enters the chamber, *E*, and flows downward through the valve to the turbine. An opening from *E* to the space below the piston allows the steam to push the piston upward against a spiral spring which pushes it downward in case the steam pressure underneath the piston is relieved. When pilot valve *D* closes the port leading from the space below the piston, the pressure maintained under the piston causes the latter to rise and with it the valve *A*, but when valve *D* uncovers the port, steam escapes from under the piston and passes around to the top, and together with the spring serves to close the valve.

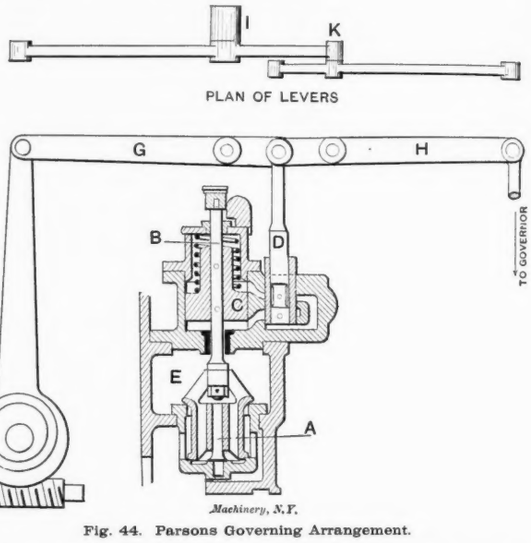


Fig. 44. Parsons Governing Arrangement.

A floating lever mechanism is used for controlling the pilot valve. At *F* is an eccentric driven by a worm and worm-wheel, which oscillates lever *G* about its fulcrum, *I*. At point *K*, on lever *G*, the lever *H* is fulcrumed. One end of lever *H* is connected to the governor and the other end to the pilot valve, *D*. The pilot valve, therefore, is controlled both by the motion of the eccentric and the motion of the governor. The eccentric keeps the pilot valve, and hence the main throttle valve, in constant oscillation, while the movement of the governor changes the positions of the limits of this motion. For example, if the turbine were running with a light load, the valve would oscillate in the lower end of its possible path of travel and would shut off steam entirely at each oscillation; but if the turbines were heavily loaded, the valve would be moved upward by the governor and its path of travel would be located higher, so that steam would flow through the valve continuously, although it would be throttled more or less as the valve moved up and down under the action of the eccentric.

Sebastian Z. de Ferranti, 1895.

The patent taken out by this inventor is to be classed with Hartman's patent of 1858 and that of the Societe Anonyme Maison Breguet, 1894. All three of these propose a compound turbine containing certain features employed in the Curtis patents now used by the General Electric Co. It is to be noted, however, that, like his predecessors, Ferranti fails to specifically state that he wishes to employ a diverging nozzle in combination with a compound turbine, which is an important feature of the Curtis type of wheel, although he says that he intends to utilize fluid in the wheel, "after complete

expansion and the acquisition of the maximum velocity," which, under certain conditions, can only be attained in a diverging nozzle. He advocates the use of superheated steam and also refers to gas turbines. The following is an extract from his specifications:

"I construct impact engines in which the working fluid impinges after complete expansion and acquisition of the maximum velocity, upon semi-circular rotating blades fixed round

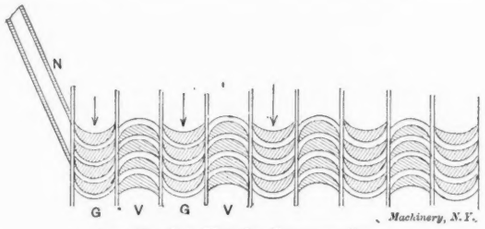


Fig. 45. One Plan for Compounding.

the rim of a motor wheel. The working fluid enters the blades at a high velocity and has its direction reversed, a portion of its energy being turned into work, and rotates the wheel, and then leaves at the other side of the blades at a diminished, though still high velocity. I then pass it through a set of standing semi-circular blades of exactly the same description as the rotating blades, but grooves in the opposite

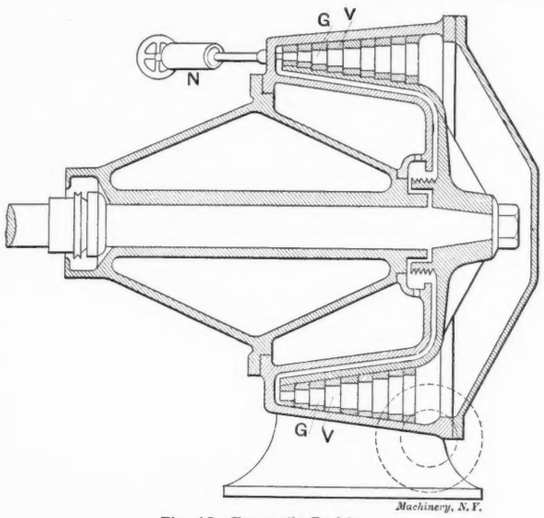


Fig. 46. Ferranti's Turbine.

direction, which reverses its direction, bringing it back to the original direction of motion, when it strikes the blades of the second wheel and delivers up a further portion of its energy and comes out at a reduced velocity. This process is repeated until the steam issues from the last set of blades with practically no useful velocity, it having given up nearly all its energy to the rotating blades of the wheel. . . . The object

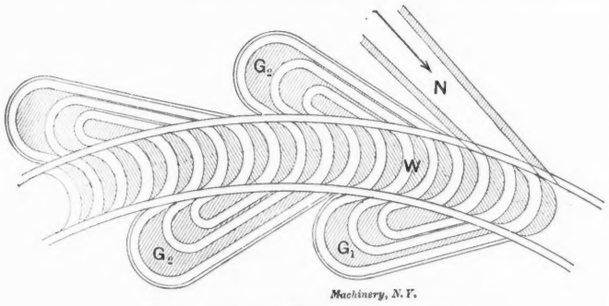


Fig. 47. A Second Plan for Compounding.

is to convert the whole of the energy and pressure in the working fluid into velocity of the particles, which then react backward and forward through the rotating and standing blades of the machine, thus constituting an impact multiple re-active engine.

"The engine may be made with one or more expansion tubes according to the power it is desired to obtain. More or less of these expansion tubes may be used and actuated by the governor according to the power required for the time being. . . . The expansion tubes stand tangentially from the periphery of the wheel and at a slight angle to the side of the wheel so as to deliver its working fluid in the most suitable position."

Fig. 45 shows the principle of his scheme, *N* being the nozzle, *G* a set of rotating vanes, *V* stationary guide vanes reversing the direction of motion, and so on. The design of turbine proposed by him is illustrated in Fig. 46, where *N* is a nozzle and *V* and *G* the rotating and guide vanes respectively, the rotating vanes being attached to a conical drum on the end of the turbine shaft and the guide vanes attached to a casing on the turbine. In this design he plans to have an increasing area for the steam as it flows through the turbine, after Parsons' plan, which is somewhat contrary to the statement of his specifications. In Fig. 47 is still another proposed arrangement in which the steam, directed by the nozzle, *N*, impinges against the wheel vanes, *W*, and is then taken up by the U-shaped passages, G_1, and returned to the wheel vanes, where it is again taken up by the U-shaped passages, G_2. This is another modification of the schemes advanced by Wilson, Perrigault & Farcot and a number of other early inventors, and, as previously stated, later by Profs. Riedler and Stumpf.

Curtis, 1896.

The important group of patents taken out in this year by Mr. C. G. Curtis, inventor of the turbine manufactured by the General Electric Co., covers most of the basic principles of this turbine. The leading feature of the Curtis machine is the combination of a diverging or expanding nozzle with a compound turbine wheel, although other features are included which had been found by the inventor to be necessary to the successful operation of a turbine of this form of construction. As already stated, previous inventors have patented turbines

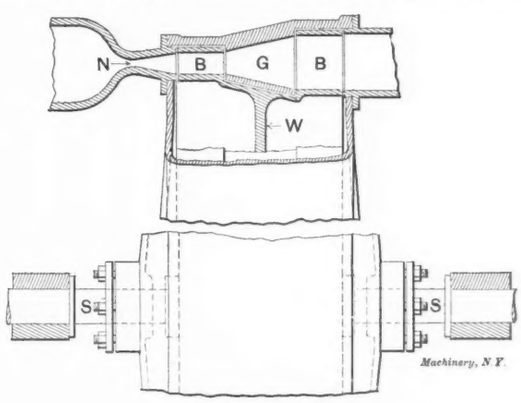


Fig. 48. Curtis' Turbine.

in which was arranged a nozzle for directing the steam against the blades of the rotating wheels of a compound turbine, but the Curtis patents are the first to clearly claim the diverging nozzle as a part of the combination, and they are, furthermore, the first ones to fully explain a practical method for carrying out the design so as to make an operative and economical machine. While the requirements for the successful operation of a compound impulse turbine were outlined by Moorhouse in his patent specifications of 1877, in which he provided for the progressive expansion of the steam from inlet to exhaust by using passages of gradually increasing areas, his patent was limited to the type of construction having a succession of compartments, in each of which is a single turbine wheel.

In Fig. 48 are shown the elements of the Curtis turbine. The shaft, *SS*, carries a turbine wheel on which are two annular rows of buckets, *BB*. At *N* is the expanding nozzle for directing the steam against the first ring of buckets, after which it passes through a group of guide vanes, *G*, to the second ring of wheel buckets. In the operation of a turbine of this type the ideal condition would be attained if the expansion of the steam could be complete in the nozzle and then it were to pass through the turbine in virtue of its inertia, giving up a part of its velocity to the first ring of buckets and the balance to the second or succeeding rings. This would allow the wheel to run at a comparatively low velocity,

depending upon the number of times the wheel was compounded. That is, if there were a single wheel, as in the De Laval type, it should run at approximately half the velocity of the steam; but if there were two wheels instead they could be run at a lower velocity so that the steam in leaving the first wheel would have a residual velocity to be taken up by the second wheel. By carrying the compounding still further a still slower speed of rotation could be used. Steam, however, is an elastic body, easily diffused, and has so small a mass that its inertia will not carry it through a succession of vanes in the above manner, unless there is an additional propelling force generated to overcome the frictional and other resistances during the passage through the vanes. This is

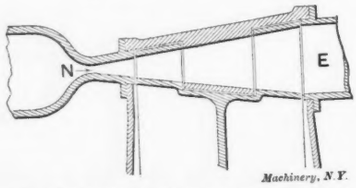


Fig. 49. Preferred Construction for Curtis Turbine.

accomplished in Fig. 48 by reversing a part of the expansion of the fluid to take place in the guide passages, *G*, which, as shown, are made diverging for the purpose. Accordingly, after the steam leaves the first set of vanes it receives an additional impulse in the guide passages before coming in contact with the second set of vanes. The preferred construction, however, and the one which is actually employed, is shown in Fig. 49. Here the steam is expanded in the nozzle, *N*, to nearly, but

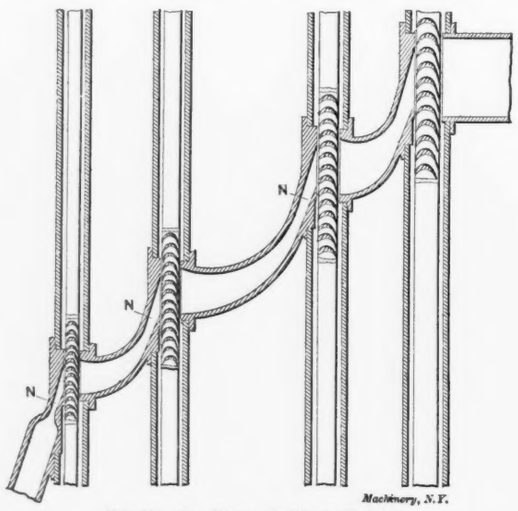


Fig. 50. One Type of "Stage" Turbine.

not quite the final pressure of the exhaust pipe, *E*. The balance of the expansion occurs during the passage between both the rotating and stationary vanes, and the pressure within these passages is, therefore, slightly in excess of the pressure within the chamber in which the wheel is rotating.

In Figs. 50 and 51 are sketches from the so-called "stage patents" of the Curtis turbines. In Fig. 50 each individual wheel is enclosed in a separate casing. Steam is directed to the first wheel by a diverging nozzle, *N*, thence it flows

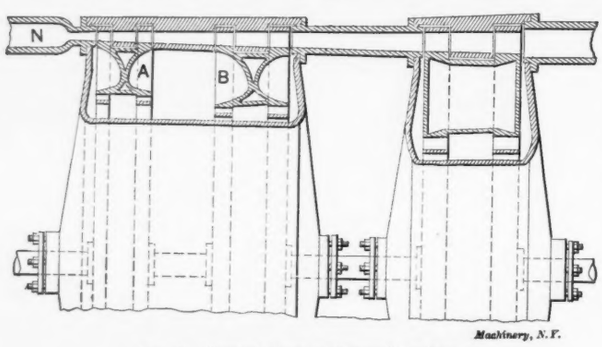


Fig. 51. Second Type of "Stage" Turbine.

through an enlarged passage, to take care of the increased specific volume of the steam, to a second diverging nozzle, *N*, which directs it against the second wheel and so on through the series. This drawing, while differing in details from the plan advocated by Moorhouse, follows very closely the principles outlined by the latter in his patent of 1877 except that Moorhouse apparently did not contemplate the use of expanding nozzles. The illustration, Fig. 51, shows each stage to be composed of one or more of the compound elements that go to make up the turbine represented in Figs. 48 and 49. In each of the two stages shown the wheel-and-bucket arrangement differs one from the other. In the first casing are wheels *A* and *B*, each carrying two sets of rotating rings or vanes, and in the second casing is a single wheel with two sets of blades. The advantage of dividing the turbine into

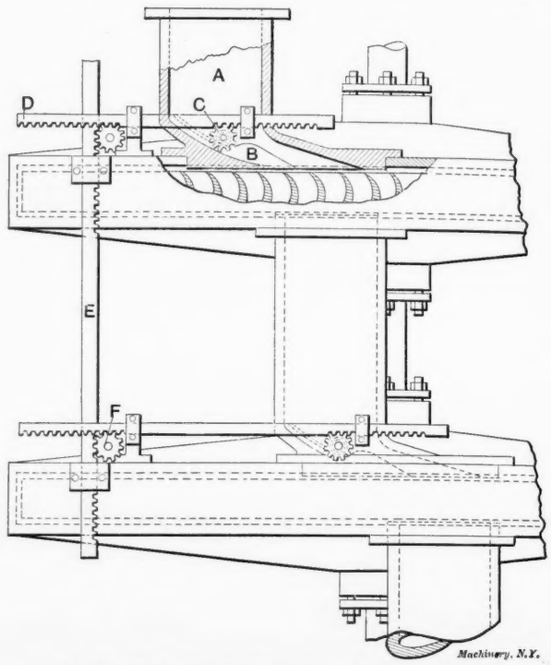


Fig. 52. Curtis plan for Governing a Compound Turbine.

stages in this way, is that there is less leakage between the guide vanes and the wheel vanes, since the differences of pressure are less; and there is also less diffusion of the steam since the number of rows of vanes for the steam to pass through in each stage is less than would be the case if all the rows were combined together in one casing and the steam were compelled to pass through them in virtue of the velocity acquired in the nozzle at the beginning.

A third patent taken out in this year deals with the problem of governing, and Mr. Curtis shows methods for changing the quantity of steam supplied to the turbine without throttling the pressure or reducing the velocity of flow. Obviously an expanding nozzle of certain proportions is adapted only to the steam pressure for which it was designed, and when the pressure is throttled the nozzle does not operate at its highest efficiency. It is proposed by Mr. Curtis to avoid this by using a nozzle of rectangular cross-section with one side adjustable in or out, regulating the quantity of steam flowing through the nozzle without making a great change in the ratio of the inlet and outlet areas. In Fig. 52 is a diagram showing the principle proposed, where the turbine is divided into two or more stages. *A* is the steam inlet, terminating in a nozzle having a sliding piece, *B*, operated by the rack, *D*, and pinion, *C*. This rack gears with another pinion, which transmits motion through the rack, *E*, to the pinion, *F*, and this in turn operates a similar sliding piece in the nozzle, directing steam against the second nozzle. The claims for the apparatus as used with a compound turbine cover first the principle of governing by changing the volume without great variations in the velocity of the steam, and second, the simultaneous and proportionate adjustment of the several passages leading to the turbine or connecting the different stages of the turbine.

PATTERN SHOP OF THE U. S. NAVAL GUN FACTORY.

EDWIN M. BIRRELL.

At Washington, the national capital, the U. S. government has established a plant for manufacturing the arms and armament of the ships of our navy. The Naval Gun Factory occupies what was formerly the Washington Navy Yard, and is situated on the Anacosta River, a branch of the great Potomac. The old buildings have nearly all been remodeled or torn down, and new shops built and equipped with machinery of the latest design. Large tracts of adjoining land

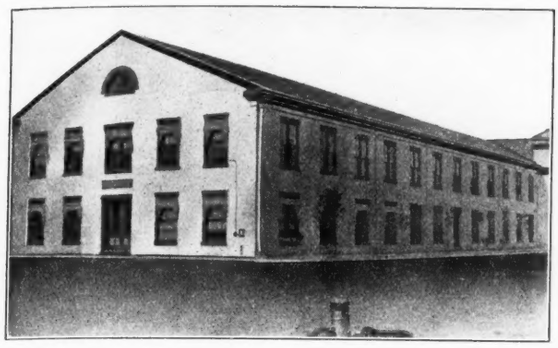


Fig. 1. Exterior of Pattern Shop—one of the Finest in the Country.

have been purchased for the extensions that will naturally take place on account of the great amount of work required to properly arm and equip our growing navy. The converting of the navy yard into the Naval Gun Factory was commenced under the administration of Hon. W. C. Whitney, Secretary of the Navy, and has grown from a small plant doing repair work on the ships to the present efficient one, capable (except for the heaviest forging and casting) of doing any of the work required in the manufacture of all guns and their mounts now in use in the navy. In this plant the government has gathered mechanics of the various trades from all parts of the country, and at the time of writing the force amounts to about 3,800 men.

One of the most important parts of the plant is its pattern shop. While the city of Washington outside the Naval Gun Factory employs fewer than half a dozen patternmakers, in this shop about fifty men find employment. It is here that the ideas of the inventor or designer assume their first tangible form. All machinery for the proper handling of guns and for furnishing ammunition to the same is designed at the Bureau of Ordnance, at the Navy Department or at the factory itself. Drawings from these designs are given to the patternmaker, who makes the wooden patterns from which castings of brass, iron or steel are taken.

The pattern shop, together with the other shops devoted to the manufacture of ordnance, is under the supervision of Capt. E. C. Pendleton, U. S. N., who is serving his second term as superintendent of the Naval Gun Factory. During his terms of office he has supervised some of the most important work needed to convert the old navy yard into the excellent plant our government now possesses. Capt. Pendleton is at present engaged in directing the installation of a new heating and power plant, which is to cost something like $750,000. Mr. M. A. Lynch is the foreman of a group of departments of which the pattern shop is one. Until about a year ago the pattern shop was under the immediate control of I. McKim Chase, a gentleman of national reputation as a patternmaker, and theauthor of "The Screw Propeller," "The Art of Patternmaking," and of numerous magazine articles. Mr. Chase was connected with the pattern department of the yard for thirty years prior to his death. Mr. B. M. Aitcheson is now the master patternmaker.

The pattern shop, situated in the southwest end of the yard, is a two-story brick building 250 feet long by 64 feet wide. It was entirely remodeled three years ago and is today pronounced to be one of the finest woodworking establishments in the country. The old machinery has been replaced by over seventy machines of the newest type and with the latest improvements. The first floor is occupied by joiners engaged in the manufacture of ammunition chests and boxes for holding shells of every size, wheels for field-gun carriages and limbers, file cases, sponge heads and handles, all kinds of cabinet work as desks and work benches, and indeed all varieties of machine woodwork. The second floor is used by the patternmakers. Fig. 5 is a view of the river from the windows, while Fig. 2 gives a view of the interior of this shop, showing the work benches on the right and the machinery on the left, also a number of unfinished patterns. It is here that the important work is performed. The benches, which are designed to accommodate two mechanics, are new, well-made, and equipped with the latest Emmert vises. They are near the windows and run at right angles to them, thus affording ample light—one of the most necessary adjuncts of a pattern shop. The entire building is provided with the Sterling blower and pipe system by means of which all shavings, dust, etc., are forced by air through pipes leading from the

Fig. 2. Interior View, showing one Floor of Pattern Building.

benches and various machines to large receptacles outside the building. These large tanks, as they are called, are so arranged that carts can stop beneath them and the driver can, by pressing a lever, empty the contents into the carts. Fig. 4 shows some of the large pipes leading from the blowers, also a tank on the north side of the shop. For use on

cloudy days, or in the event of night work, a system of electric lights is installed on both floors. At each end of the building are elevators for the transportation of patterns, lumber, etc.

Fig. 3. Pile of Heavy Castings for Gun Mounts.

The pattern makers construct patterns for all the machinery used in manipulating the guns on board the ships of our navy, on the small torpedo boats as well as on the large battleships. In other words, patterns are made for the machinery required to mount the various size guns, for elevating and training them, and for loading devices by means of which the ammunition is brought in metal cars from the magazines of the ship to the breach of the guns; while patterns are also made for the different size shells, that is to say, for the ammunition itself. A group of castings is shown in Fig. 3 secured from patterns made in this shop and consisting of deck lugs, slides, and top carriages. A great deal of difficulty was encountered with the first steel casting made some years ago on account of the irregular shrinkage that occurred, but experience has corrected this and now there is very little complaint. Shrinkage scales provided by the government are used, and graduated to suit the various shrinkages. The scale is as follows: Iron, ⅛ inch to the foot; bronze, 15-100 inch to the foot; and manganese bronze and steel, 3-16 inch to the foot. Of course on large patterns the shrinkages have to be applied as experience shows to be best, as, for instance, in the construction of the pattern for the 8-inch deck lug shown in Fig. 6, where the shrinkage used was as follows: Length, 3-16 inch to the foot; width, ⅛ inch to the foot; height, 15-100 inch to the foot. The same shrinkages were allowed on the core box, except in the width, where only 5-200 inch was allowed. The castings secured from this pattern are estimated to weigh 5,335 pounds each, and form part of the mount for guns of this size on the U. S. S. *Virginia* and other ships of her class.

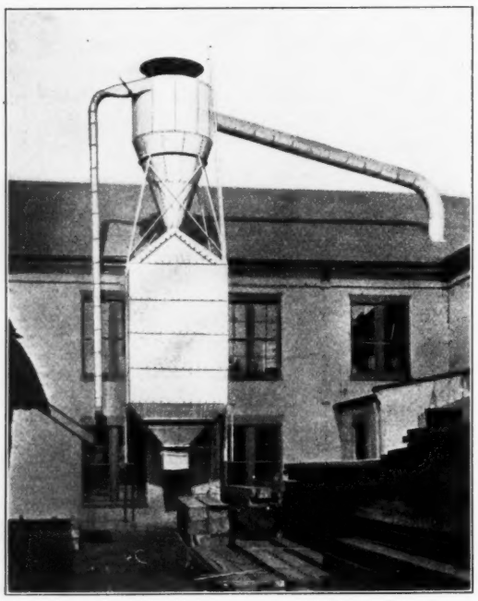


Fig. 4. Tank and Blower System for Gathering Shavings.

The patterns in this shop are made principally of white pine. Difficulty is encountered in securing well-seasoned lumber devoid of knots, hence in winter almost all the lumber used is subjected to a process of drying in the dry-kiln connected with the shop. Standard patterns of the smaller size, from which a large number of castings are required, are made of bay wood which, on account of its hardness, is very desirable for patterns that are often used. An example is: A pair of helical miter gears is used on the large 110-ton crane in the north gun shop of the yard. They are constructed of bay wood with the teeth made of cherry.

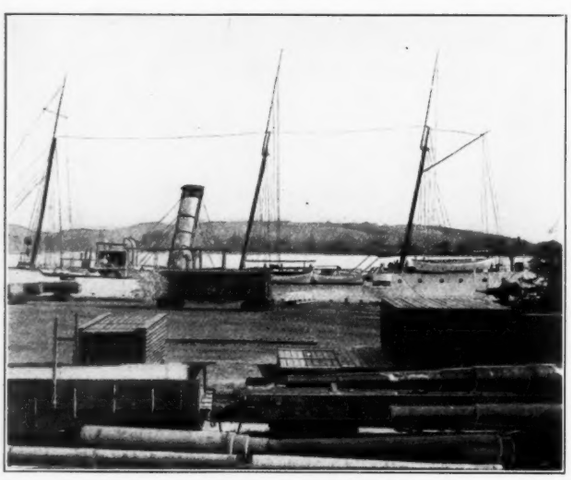


Fig. 5. View from Pattern Shop Window.

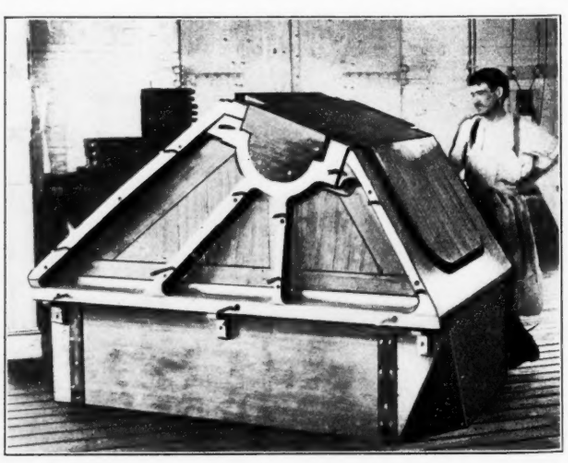


Fig. 6. Example of Pattern Work.

Each tooth is secured to the rim of the wheel by a dovetail which allows the tooth to be removed and worked off after being turned and laid off to the proper dimension on each end. Although their construction required some time, for they are a type of the costly pattern, it was an act of economy in the government to build a pair of these patterns for its own use, since patterns of this kind will, with good usage, last for a number of years.

Some idea of the amount of work done in this shop may be gained from the fact that over 1,500,000 feet of lumber are annually used in the pattern shop. A complete record is kept of all the patterns made. After being completed by the patternmaker, they are weighed and reported finished, and, after inspection by the officer in charge, are stenciled with name and number and sent to the foundry to be molded. The required number of castings having been secured, the patterns are sent to the pattern loft, a large building used for storing them. This building is now stored with a number of patterns whose value can be inferred when it is stated that the registered number of patterns is nearly 8,000, while in many cases months of labor were required for the construction of a single pattern. All patterns are given several coats of yellow shellac with core prints of black.

* * *

SOME REFINEMENT OF MECHANICAL SCIENCE.

In his address at the annual meeting of the A. S. M. E., held in New York last month, Mr. Ambrose Swasey, the retiring president, began by saying a few words concerning the growth and progress of the society since its organization. Continuing, he said, "I wish to speak of a few of those methods and mechanisms which have been developed and perfected to such a degree of refinement that they may be considered as almost beyond the practical, and yet were it not for such refinements they could not possibly be made to serve the utilitarian purposes which make them of such inestimable value to us all."

Mr. Swasey spoke first of the progress made in the accurate division and measurement of time, saying that before the christian era the length of the solar day had been fairly well defined, but it was not until 1582 that astronomers computed the exact length of the solar year, and with such precision did they then determine it that our present calendar will continue on for twenty thousand years, with an error not to exceed a single day. The device used for this calculation is still shown in the calendar room of the Vatican Observatory. In the center of the room, forming a part of the floor, is a large marble slab with a fine line cut exactly in the true meridian, and upon the line is a special mark indicating the altitude of the sun at noon of a certain day. On the south wall, near the top of the room, is a small aperture through which the direct rays of the sun pass at noon, projecting a bright spot on the meridian line. In this day of instruments such a simple device would hardly be thought of use, yet it served its purpose admirably and was considered one of the greatest scientific achievements of that age.

Since an unknown time the day has been divided into twenty-four hours, measured in turn by the sun-dial, the hour glass, the water clock, and from the twelfth century on, by clocks of the present type. The first water clocks used by the Greeks consisted of two jars so arranged that the water from the upper ran into the lower, and the time of day was determined by measuring the water remaining in the upper jar. To this day water clocks are used extensively in the East, and in the city of Canton even the standard time is kept by an improved water clock which has been running for eight hundred years, and which, notwithstanding its long service, shows no perceptible wear. This improved clock consists of four jars placed one above the other, and the hour is shown by the position, in reference to a cross bar, of a graduated upright attached to a float in the lowest jar.

Galileo's discovery of the isochronism of the pendulum was of great value in many respects, but in none more so than in its application to the measurement of time. Soon after that great discovery, the English clockmaker, Graham, invented the mercurial pendulum by which the variation in length due to temperature was compensated, and some years later Harrison, another English clockmaker, invented a compensating pendulum consisting of a series of metal bars having different coefficients of expansion. Since that time every part of the clock has been the subject of study and improvement, and they are now made with such precision and delicacy that in testing them the question is, within how small a fraction of a second will they run. Some of the finest astronomical clocks are inclosed in glass or metal cases in which a partial vacuum is maintained, wound automatically by electricity, and set up in underground vaults so that errors due to vibration, change of temperature or barometric conditions are made practically impossible. A clock installed at the Observatory of Case School of Applied Science at Cleveland, running under these favorable conditions, has a mean error of fifteen one-thousandths of a second per day, and a maximum error for several months of but twenty-two one-thousandths of a second per day. This is a notable example of the present state of the art of clock-making, and shows the wonderful precision with which minute intervals of time can be measured. From the time of the invention of Peter Hele, in 1477, of the "Nuremburg Animated Egg" or "pocket clock," which required winding twice a day and varied an hour and a half in the same length of time, the development of the watch has kept pace with the "Mother Clock."

The larger watch, or ship chronometer, with its escapement so delicately made and adjusted that it must always be kept in the same position, was greatly improved through the efforts of the British Government in 1714 by offering rewards of ten, fifteen and twenty thousand pounds to any who should make chronometers that would run so accurately that the longitude of a ship at sea could be determined within sixty, forty and thirty miles; and Harrison, the inventor of the compensating pendulum and the compensating balance, which is now used in watches, succeeded in making a chronometer, which, after being tested on a long voyage, was found to run so closely that the position of the ship was determined within eighteen miles, and he was therefore paid the full award of twenty thousand pounds. That historic chronometer, which marked a new era in navigation, is now numbered among the treasures of the Greenwich Observatory.

Modern ships are equipped with chronometers so accurate and so reliable, and with sextants of such precision that navigators can determine their position in latitude and longitude within a few miles. Therefore, with the increased speed of the powerful ships carrying hundreds or even thousands of passengers, together with their valuable cargoes, the methods and instruments used in navigation have been so improved as to greatly diminish the dangers in crossing the seas.

The perfection attained in the measurement of time, which is of such great practical value in nearly every sphere of life, would not have been possible were it not for the even greater refinements that have characterized the methods and instruments used by the astronomer in determining the length of the day and of the year, which are the fundamental standards of time.

After saying substantially the above Mr. Swasey continued his address as follows:

"The division of the circle and the measurement of angles have ever been among the unsolved problems of the astronomer, yet in the instruments used by him, circles have formed a most important part.

Long before the telescope was invented, Tycho Brahe, the Danish astronomer, "the founder of Modern Astronomy," constructed for his observatory, instruments of various kinds having graduated circles and arcs of circles. His instruments for the most part were improvements on those used by Arabian astronomers in the eighth and ninth centuries, and these, in turn, were copied after similar instruments used by the Greeks and Egyptians, a thousand years previous, and it is supposed that such instruments were used by the Chinese at an even earlier period, so that graduated circles have come down to us from the far-off ages.

The longer the radius the more accurate the graduations, was the principle upon which the early instruments were

made. The Arabians, in about the year 1000, built a sextant with a sixty-foot radius and a quadrant with a twenty-one-foot radius, but to Tycho Brahe is due the credit of constructing instruments having circles, much smaller in diameter and graduated with a greater precision than ever before. It was by the use of such improved instruments of his own making, and by his observations which were made without a telescope or any means of magnification, that he was able to give the positions of a large number of stars within less than one minute of arc from the positions given by modern astronomers.

The first circular dividing engine was made in 1740 by Henry Hindley, of New York, for cutting the teeth of clock wheels, and it is interesting to note that in the same year Huntsmann, another clockmaker, of Sheffield, invented the process of making crucible steel, that he might have a metal suitable for the springs of his clocks.

Of the several engines constructed later, the one most successful and representing the greatest progress, was that made by Ramsden, in 1777. This engine, automatic in its movements, was made especially for graduating circles, and because of the great precision with which he divided the circles of the instruments used by the Government, the Board of Longitude awarded him the sum of six hundred and fifteen pounds.

In a dividing engine the chief essential is that the spindle carrying the master-plate shall be as nearly round and as closely fitted in its bearings as is possible, for the degree of excellence with which that work is done determines how closely a circle can be divided.

It seems almost incredible that a well-lubricated spindle of four inches in diameter at its largest part and tapering three-quarters of an inch to the foot, can be made so nearly round and so closely fitted in its bearings that a movement of one-thousandth of an inch in or out of its bearings, will in one case cause it to turn with difficulty, and in the other with perfect freedom; yet this has been found to be within the limits of mechanical refinements.

The greatest accuracy thus far attained in such engines, is one second of arc, which arc, with a radius of three miles equals one inch, and at twenty inches, which is the radius of the silver ring upon which the graduations on the master-plate are made, a line one-thousandth of an inch in width is equal to twelve seconds of arc, or twelve times the accumulated errors of any number of divisions, or twenty times the greatest error of any single division.

In automatically graduating a circle, it has been found to be impracticable to cut more than six lines in a minute, and it requires about thirty-three hours to divide a circle into two-minute spaces. As with the running of the finest clocks; the best results can only be obtained when the engine is surrounded with every favorable condition possible. Instead of the large circles and sectors used by the ancients, they have been made smaller in diameter as the methods for graduating have been improved, until those of the more modern instruments are seldom more than thirty inches, and some of the latest meridian instruments have circles of but twenty-five inches.

The smaller circles, which can be made and graduated with greater precision than the larger ones, are also less liable to change in form, owing to their weight and the variation in temperature, and with the aid of the reading microscope the results obtained would not be possible with the larger circles. A twenty-five-inch circle read with a microscope having a power of forty, would be equivalent to a circle of about eighty feet in diameter, and a single second of arc as seen through the microscope would be equal to 0.0024 of an inch, a quantity easily subdivided.

The cross wires, which are but common spider lines, because of their fineness and the remarkable qualities they possess, are indispensable in micrometric work.

That the repulsive and even dangerous spider has plenty of enemies among the human family, there can be no doubt, yet if the value of the contributions which it has made to the cause of science were generally known, it would surely have a greater number of friends than at present, and most certainly the astronomer will say naught against it, for after the experience of many years he has found that the spider furnishes the only thread which can be successfully used for the cross wires of his instruments.

The spider lines mostly used are from one-fifth to one-seventh of a thousandth of an inch in diameter, and in addition to their strength and elasticity, they have the peculiar property of withstanding great changes of temperature, and often when measuring the sun spots although the heat is so intense as to crack the lenses of the micrometer eye-piece, yet the spider lines are not in the least injured. The threads of the silk-worm, although of great value as a commercial product, are so coarse and rough compared with the silk of the spider that they cannot be used in such instruments. Platinum wires are made sufficiently fine, and make most excellent cross wires for instruments where low magnifying powers are used, yet as the power increases they become rough and imperfect.

Spider lines, although of but a fraction of a thousandth of an inch in diameter, are made up of several thousands of microscopic streams of fluid, which unite and form a single line, and it is because of this that they remain true and round under the highest magnifying power. An instance of the durability of the spider lines is found at the Allegheny Observatory, where the same set of lines in the micrometer of the transit instrument has been in use since 1859.

In the realm of the measurements of minute linear distances, and the perfection of curved and flat surfaces, the refinements are even greater than those pertaining to the measurement of time and of angles. Most important in the linear dividing engine is the screw, and although much had been accomplished in bringing such engines to a high degree of excellence, it was for Prof. Rowland to make an engine which has a practically perfect screw; and without doubt it is in all respects the nearest perfect of all the mechanisms that have been employed for ruling lines exactly parallel and equally spaced.

The Rowland engine was made especially for ruling diffraction gratings which are made of speculum metal, and with it a metal surface has been ruled with 160,000 lines, there being about 29,000 to the inch, and as many as 43,000 lines to the inch have been ruled. The gratings mostly used have from 14,000 to 20,000 lines to the inch, and with such exactness is the cutting tool moved by the screw that the greatest error in the ruling does not exceed one millionth of an inch.

The production of these gratings, which has enabled the physicist in his study of the spectrum to enter fields of research before unknown, has not only called for the highest degree of perfection ever attained in the spacing of linear distances, but it has also called for a refinement most difficult in the optical surfaces upon which the lines are ruled. To Mr. Brashear was given the problem of producing such surfaces, and notwithstanding the many difficulties encountered in working and refining the speculum metal plates, he has made many hundred plates with surfaces either flat or curved with an error not to exceed one-tenth of a wave length of light, or one-four-hundred-thousandth of an inch.

The established standards of length which are the yard of Great Britain and the meter of France, being made of metal, and liable to destruction or damage, Prof. Michelson conceived the idea of determining the lengths of these standards in wave lengths of light, which would be a basis of value unalterable and indestructible. For the purpose of carrying out these experiments, the interferometer was constructed, an instrument which required the highest order of workmanship and the greatest skill of the optician. Again Mr. Brashear proved to be equal to the occasion, and made for the instrument a series of refracting plates, the surfaces of which were flat within one-twentieth of a wave length of light, with sides parallel within one second. This was the most difficult work ever attempted in the refinement of optical surfaces.

Professors Michelson and Morley devised a method for using the interferometer for making the wave length of some definite light an actual and practical standard of length. So satisfactory was the result that Prof. Michelson was invited to continue the experiments at the Bureau of Weights and Measures, at Sèvres, France, where the standard meter, which is kept in an underground vault and inspected only at long

intervals, was used for that important work, which occupied nearly a year. The final result of the experiments shows that there are 1,553,164.5 wave lengths of red cadmium light in the French standard meter, at 15 degrees Centigrade. So great is the accuracy of these experiments, that they can be repeated within one part in two millions. Should the material standard of length be damaged or destroyed, the standard wave length of light will remain unaltered, as a basis from which an exact duplicate of the original standard can be made. These two marvelous instruments, the Rowland dividing engine and the Michelson interferometer, show the possibilities in the perfection of linear divisions and the standards of length.

* * *

CONTEMPORARY TECHNICAL EDUCATION.*

The young man who is to follow a narrow routine through life will not have added much to his efficiency, as a machinist, by the long elaborate course of the technical school. For those constitutionally deficient in ambition, or for those unfortunates who can never comprehend the art of getting on in the world, these four extra years are ill spent at school, but there are plenty of young men for whom this training of the technical school is the best possible training, and there is plenty of opportunity for a larger number of these men than all of our present schools can graduate.

Men cannot be shaped on the interchangeable system of the American machine shop; each will be a "special," and, as already remarked, there will be produced "firsts," "seconds," and "thirds," but fortunately the demands for all types and grades exceeds the possible supply for years to come. Among the graduates some will possess that rare faculty for which "initiative" is the phrase of the day, and among these there will be some who will possess that quality of balance and judgment, and attain such knowledge of men, that they will become great leaders—the captains—will establish their own industrial works or be called to the $10,000 positions which are always so hard to fill right. Others, without this business insight, but perhaps more learned and more skillful in engineering, will design machines and bridges, supervise factories, become the lieutenants and fill the $4,000 and $2,000 positions, and still a larger number will do noble work as the sergeants, corporals and privates and be made better men by the broadening of their minds.

The training of no school can make the square peg fit easy in the round hole, and, out of a hundred boys, but few are born with the ear of a musician or the eye of an artist, or with the observing, inquiring, ingenious, imaginative mind which schools can stimulate but cannot create, and without which conspicuous success in constructive engineering is impossible. But for the young man so fitted by nature, a technical school of broad scope and high aim is a royal road. The old statement that "There is no royal road to learning" is untrue. The man of affairs has come to understand that the technical school is a royal road to learning, a shorter road, an easier road, through a more beautiful landscape, and in equal time attaining a broader outlook.

A man with the earnestness and patience of John Brashier, the strong purpose of John C. Hoadley, the rugged common sense of Edwin Reynolds, the strong, kindly heart and quick intelligence of John Fritz, or the genius of Edison, may reach an equal height by a longer and more arduous road, and, like the athlete, increase his strength and harden his endurance in the greater effort, but the royal road of the technical school, in its four years, may, from its small group, gathered part by chance and part by process of natural selection from more than ten thousand school boys, bring perhaps ten to the point that otherwise not more than one or two or three could hope to reach in twice these four years.

* * *

FIRE PROTECTION IN MARSHALL FIELD DEPARTMENT STORE, CHICAGO.

The value of private fire apparatus for the protection of individual buildings and adjoining property was thoroughly demonstrated in the Baltimore and Toronto fires, and, in fact, the Baltimore fire department admits that many buildings on the immediate margin of the devastated tract were saved only by the effective work of private apparatus. These buildings were supplied with either standpipes or pumps connected with wet-pipe interior sprinklers and dry-pipe sprinklers for protection from outside fires, storage tanks holding from 1,500 to 15,000 gallons being placed on the roofs. Besides saving the buildings in which they were located these equipments stopped the advance of the fire, and undoubtedly many more buildings would have been destroyed in the absence of their efficient service. The buildings and contents protected by private apparatus in Baltimore were valued at five million dollars and at Toronto the saving from private protection was similar in extent.

The fact that such apparatus is on the ground, in position and ready for action averts the destruction of much property by both fire and water. A fire is usually well under way before the city fire companies can arrive, arrange their hose lines and make necessary couplings and connections. A drenching of the entire building is then often required, while a comparatively small amount of water would have put out the fire in the first place. The immediate availability of private fire apparatus gives it a great advantage over any other form and has long been employed by manufacturing concerns. Such apparatus usually consists of direct-acting pumps, steam-driven. A large installation of the kind, however, in one of the largest department stores is of interest because it is electrically-driven and seems to meet the needs of independent apparatus for office buildings and other structures in cities. An important consideration in selecting an apparatus of this sort is the readiness with which electric power can be obtained and utilized; there being hardly a building where a reliable supply of electric current cannot be cheaply and easily obtained. There is, further, no maintenance expense as with steam apparatus.

The installation referred to is in Marshall Field's immense department store, Chicago. The outfit consists of a Laidlaw-Dunn-Gordon duplex underwriter pump connected by single-reduction gearing to a water-proof electric motor. The pump cylinders are eight inches in diameter by twelve inches stroke, having a theoretical capacity of 700 gallons per minute at 600 R. P. M. against 140 pounds water pressure. There are large pressure and vacuum chambers, required by the underwriters' specifications. The pump is thoroughly rust-proof in all moving or wearing parts, insuring prompt and smooth running when occasion arises.

The motor, which was furnished by the Chicago Edison Co., is shunt-wound for 220 R. P. M. at 230 volts and is inclosed, all connections being carried through pipes screwed into the frame, so that the device may be flooded without affecting its action. The fields and armature coils are cooled by fans on the armature shaft.

* * *

THE PANAMA CANAL PROBLEM.

The Panama Canal is likely to be a very costly undertaking for the United States Government, and the time of its building will probably be equal to that of a generation, if present estimates are right. Chief Engineer Wallace, of the Isthmian Canal Commission, has reported that a sea level waterway across the Isthmus, although it would cost far more and take much longer to complete than the three other canal projects under consideration, would in the end be the best. In his opinion the cost of the sea level canal would be $300,000,000, as against $200,000,000 for a 90-foot level canal, and he thinks that twenty years would elapse before its completion, or ten years more than for a canal with locks. Here apparently is a great opportunity for the development of machinery that shall make as great an advance in such work as was done on the Chicago Drainage Canal. It is imperative that the time of construction be reduced; every year that its completion is delayed means, in effect, greatly increased cost of construction when the loss to commerce is taken into account. It is a chance to put to use on an enormous scale the knowledge gained in hydraulic placer mining in the West. Both the loosening and transportation of the material to the sea might be accomplished rapidly in this manner.

* Extract from an address by Mr. John R. Freeman at the Case School of Applied Science, May 11, 1904.

VARIABLE SPEED MOTORS.—9.

THE CUTLER-HAMMER VARIABLE-SPEED CONTROLLERS

WM. BAXTER, JR.

The Cutler-Hammer Mfg. Co., of Milwaukee, make a number of designs of controllers for variable-speed motors, some of which are of the drum type while others are of the slate front, or clock dial type. To describe all these designs would require too much space, but as many of them are but slight modifications of others, the description of a few, each one typical of its class, will serve to give a fair idea of their

Fig. 1. Controller, Non-reversing Type.

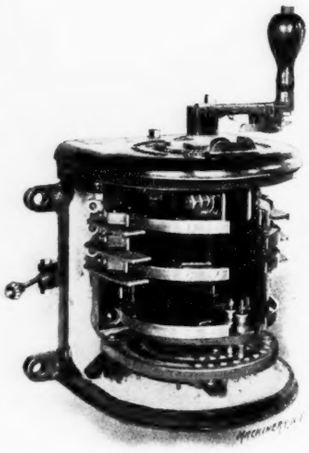


Fig. 2. Controller, Reversing Type.

construction and operation. These controllers are used in connection with many different designs of motors made by concerns that do not manufacture their own controllers.

Fig. 1 shows a non-reversing drum controller with the casing removed. A diagram showing the various contacts of this controller and their connections with each other, with the motor and the supply wires, is given in Fig. 4. Fig. 2

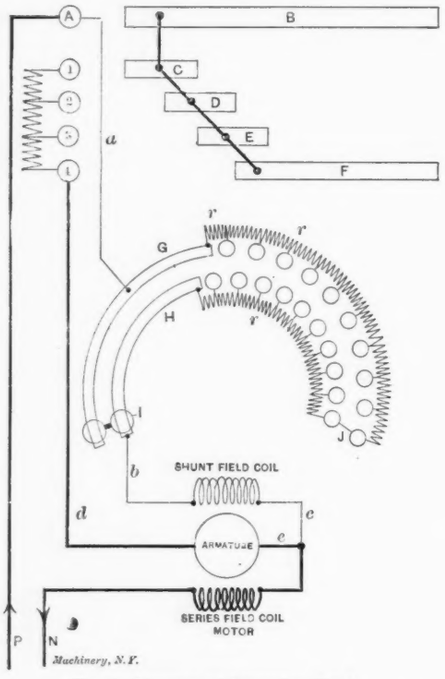


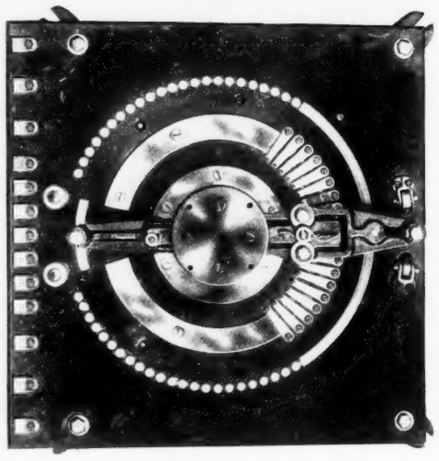
Fig. 4. Diagram of Controller, Fig. 1.

shows a reversing controller of the drum type, and a diagrammatic representation of the contacts and connections is given in Fig. 5. Fig. 3 shows a slate front controller of the reversing type. The development of this controller is shown in Fig. 6.

In these three controllers the speed variations of the motor are effected by introducing resistance in the shunt field circuit, that is, by field regulation.

Construction and Operation of the Non-reversing Drum Controller.

The diagram, Fig. 4, illustrates the arrangement of the contacts and circuit connections of the non-reversing drum controller. In this diagram the motor, which is represented as of the compound-wound type, is located at the bottom and the parts above it are the controller. The circles *A*, 1, 2, 3, 4, are stationary contacts that press upon rings *B C D E F*, mounted on the drum. These contacts and rings are clearly shown in Fig. 1. The drum rings *B C D E F* are electrically connected with each other. When the drum is turned to the first position, *B* and *C* make contact with *A* and 1, and then the line current from *P* passes from *A* to *B* thence to *C* and to 1. The armature starting resistance is connected, as shown, between the stationary contacts 1, 2, 3, 4, hence when only *A* and 1 are connected with the drum rings, as is the case in the first position, the current must pass through all the starting resistance to reach wire *d*, and thus the armature. From the armature through wire *e* the current passes to the series field coil of the motor and thence to line wire *N*. The



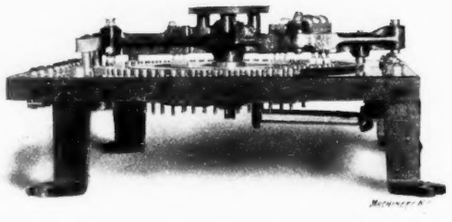


Fig. 3. Controller, Slate Front, Reversing Type.

current for the shunt field starts from *A* through wire *a* to segment *G*, thence through the sliding contacts *I* to *H* and by wire *b* to the field coil, from which it passes through wire *c* to *e*.

The further rotation of the controller cylinder causes the rings *D E* and *F* to come in contact with 2, 3 and 4 one after the other, and thus the starting resistance is cut out of the armature circuit in three sections.

The segments *G* and *H* and the circular contacts following them are stationary and are located at the bottom of the controller, as clearly seen in Fig. 1. The sliding contacts *I*, which are electrically connected with each other, are carried by the cylinder, and slide over *G H* and the small contacts as the cylinder advances. While the cylinder is advancing to cut out the starting resistance, *I* slides over *G* and *H* and reaches the ends near the circular contacts, by the time *F* connects with 4. If the controller is left in this position, the motor will run at its lowest speed. If a higher speed is desired, the controller handle is advanced and then *I* slides over the circular contacts and cuts into the shunt field coil circuit more or less of the resistances *r r r*. When the controller handle is rotated as far as it will go the sliding contact *I*

will rest on the end contacts *J* and all the resistances *r r r r* will be cut into the field circuit and the motor will be running at its highest velocity. Any speed between the high and the low can be obtained by moving the controller handle until *I* rests at the proper point. As the field resistance *r r r* is divided into many sections and these can be cut out one at a time, many different speeds can be obtained.

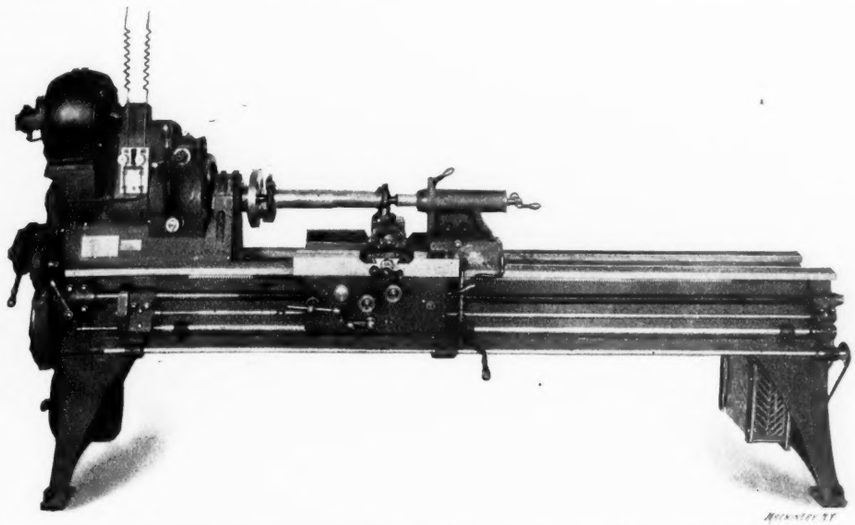


Fig. 7. "Northern" Variable-speed Motor, operating Springfield Lathe, with Cutler-Hammer Slate Front Controller.

The Reversing Type of Drum Controller.

The arrangement of the contacts and connections of drum controller of the reversing type is shown in Fig. 5. As in Fig. 4, the motor is located at the bottom of the diagram, and is of the simple shunt type. The controller can be used with a compound wound motor, however, by simply connecting the series field in either one of the wires *P* or *N*, but not in the armature wires 7 and 8, for in the latter position the reversal of the current through the armature would also reverse it through the series field coil, and thus make the motor of the cumulative type for one direction of rotation, and of the differential type for the opposite direction.

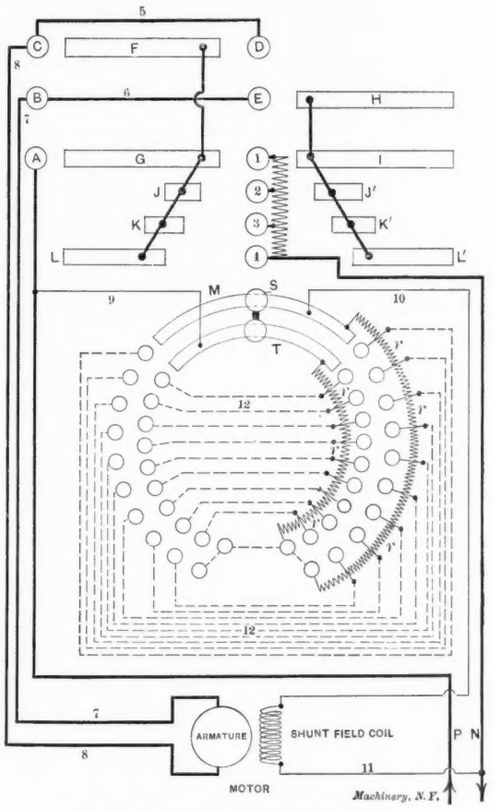


Fig. 5. Diagram of Controller, Fig. 2.

In the reversing controller there are two sets of stationary contacts, one located at the center of the diagram, and marked *D E* 1, 2, 3, 4, and the other located at the left of the diagram and marked *A B C*. In Fig. 2 these two sets of contacts can be seen one on each side of the cylinder. In Fig. 5, if the cylinder is rotated so as to move to the left, rings *F* and *G* will connect with *C* and *A* respectively, and rings *H* and *I* will connect with *E* and 1. With these connections, the current from *P* will pass to *A*, thence to *G* to *F* to *D* through wire 5 to *C* and wire 8 to the motor armature. Returning from the armature through wire 7 to contact *B* and wire 6 to contact *E* the current reaches contact 1 through the drum rings *H* and *I*. From 1 the current passes through the starting resistance connected between contacts 2, 3, 4 and thus reaches the line wire *N*. The shunt field current branches from *P* through wire 9 to segment *T*, and through the sliding contacts *S* to *M* thence through wire 10 to the field coil, and from the latter through wire 11 to line *N*.

The rings located at the lower end of the drum are arranged the same as those in Fig. 4, but are in duplicate so as to cut out the starting resistance whichever way the cylinder may be turned. The segments *M* and *T* and the circular contacts in line with them are stationary and are located at the bottom of the controller as shown in Fig. 2, and the sliding contacts *S* which are electrically connected with each other are carried by the cylinder. As with the non-reversing controller, the contacts *S* do not pass off segments *M* and *T* until after ring *L*, or *L'*, has made contact with 4. The further rotation of the controller handle carries *S* over the circular contacts and cuts into the shunt field coil circuit more or less of the regulating resistance *r r r r* according to the distance through which *S* is carried, the action being the same as in Fig. 4.

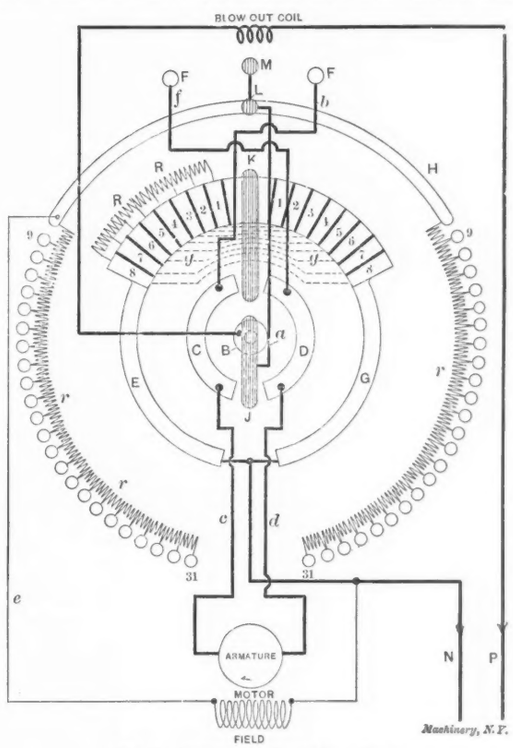


Fig. 6. Diagram of Controller, Fig. 3.

To reverse the direction of rotation of the motor, all that is necessary is to reverse the direction of the current through

the armature; in other words, the current from line wire *P* must enter the armature through wire 7 instead of through wire 8. If the controller handle is turned so as to carry the cylinder rings to the right, then rings *F* and *G* will connect with stationary contacts *D* and 1, respectively, and rings *H* and *I* will connect with *B* and *A*. With these connections it will be seen that the current from line wire *P* will pass through *A* to *I* and thence to *H* and to *B* and through wire 7 to the armature, returning from the latter through wire 8 to *C* to 5 to *D* to *F* to *G* to 1 and through the starting resistance to line wire *N*.

As the sliding contacts *S* rotate in one direction for the forward motion of the motor, and in the opposite direction for the reverse motion, the segments *M* and *T* are located in a central position and with circular contacts at each end, so that whichever way *S* may move it will cut in and out in the proper manner the field resistance *r r r r*. In these drum type controllers, as a rule, the resistances are not made a part of the controller, but form a separate structure, and for that reason the contacts on opposite sides of segments *M* and *T* are connected with each other in the manner indicated by the broken lines 12.

Arrangement of the Contacts and Connections and Operation of the Slate Front Controller.

The diagram, Fig. 6, shows the arrangement and connection of the contacts of the slate front controller illustrated in Fig. 3. The switch lever carries the connecting contacts *J K L* and *M*. Of these contacts *K* is isolated, but *J L* and *M* are connected with each other, as shown by wire *a*. The center stud *B*, on which the lever swings, is connected with line wire *P*. The two segments *E* and *G* are connected with line wire *N*. The contacts 8 8 are connected with *E* and with *G*, but the remaining contacts in this circle, that is, 1, 2, 3, 4, 5, 6, 7, are insulated from each other and the only connection between

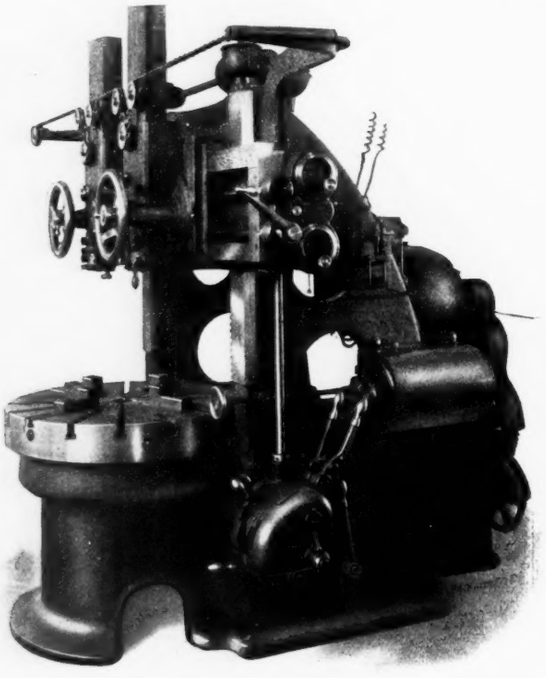


Fig. 8. "Northern" Motor operating Gisholt Boring Mill, with Cutler-Hammer Gear-driven Drum Controller.

them is through the armature starting resistance *R*. One end of the shunt field circuit is connected with segment *H* and the other with line wire *N*.

If the switch lever is turned clockwise, the current from wire *P* after reaching *B* will pass through *J* to *C* and thence by wire *c* to the motor armature, returning to *D* through wire *d*. From *D* through *K* the current will pass to 1 and thence, through the connection shown in broken lines *g*, to the left side of the controller, and through the starting resistance *R* to segment *E* and to line wire *N*. The field coil current will start from *J* through wire *a* to contact *L* and to *H*, thence through wire *e* to the field coil, and from the latter to wire *N*.

As the switch lever is advanced, *K* will pass over the contacts 2, 3, 4, etc., to 8, and thus cut out the starting resistance. If the switch lever is left with *K* resting on 8, the motor will run at the lowest velocity, but if it is advanced until *L* rests on 31 the speed will become the maximum, as then all the field regulating resistance *r* will be cut into the circuit.

If it is desired to run the motor in the opposite direction, the switch lever is turned counter-clockwise, and then the current from wire *P* will pass from *B* through *J* to *D* and thence through wire *d* to the armature, passing through the

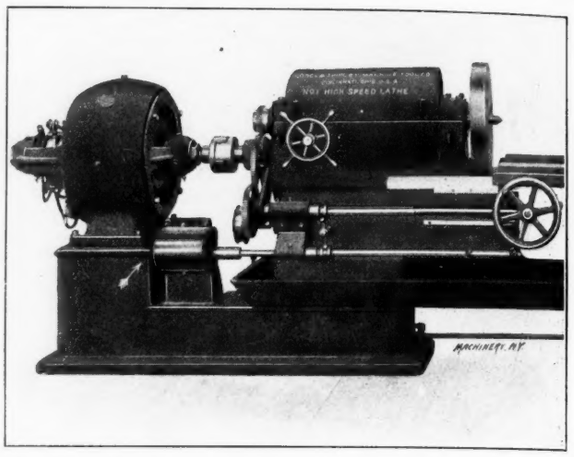


Fig. 9. Lodge & Shipley Lathe operated by "Northern" Motor, with Cutler-Hammer Direct-driven Drum Controller.

latter in the opposite direction. From the armature the current will return through wire *c* and reaching segment *C* will pass through *K* to the contacts 1 2 3—8 to *E* and to line wire *N*.

At *F F* are located contacts the purpose of which is to prevent sparking between *J* and *C*, or *D*, when the motor is stopped. As will be seen, the circuits would be complete if the contacts *F F* and the wires *b* and *f* were removed, but in returning to the stop position, *J* would separate from *C* or *D*—whichever one it happened to be in contact with—and a heavy spark would be produced at the point of separation. With *F F* and wires *b f* added, when *J* breaks contact with *C* or *D*, the circuit is still kept closed because at that instant the contact *M* is resting on one of the *F* contacts. After *J* has broken contact with *C* or *D*, *M* separates from *F* and thus the circuit is opened at this point, and it is here that the sparking occurs. These isolated contacts can be made large so as to stand heavy sparking without serious injury; but for the purpose of reducing the spark as much as possible, a blow-out coil is located so as to blow out the spark when *M* separates from either one of the *F* contacts.

The contacts 9—31 on either side of the circle are not connected with each other in the manner indicated in Fig. 5, because in this type of controller it is more advantageous from a mechanical standpoint to provide a double set of field resistances *r r*. The starting resistance *R* is not made in duplicate as it is more desirable in this instance to cross-connect contacts 1, 2—8 as shown by the broken lines *g*.

A slate front controller of the type above described is shown in Fig. 7 mounted on an "Ideal" Springfield lathe, which is driven by a Northern variable speed motor. The controller is placed under the lathe bed at the tailstock end, and is operated by means of a shaft running along the side of the bed under the carriage, in a manner that is clearly shown.

Fig. 8 shows a drum type controller mounted on a Gisholt boring mill driven by a Northern variable speed motor.

Fig. 9 shows a Lodge & Shipley lathe with Cutler-Hammer direct-driven drum controller, driven by a Northern variable speed motor.

* * *

It is reported that the Southern Pacific Railroad Company are experimenting with an internal combustion locomotive built on the Diesel principle.

ELECTRIC REPAIRING.

ARMATURE WINDING.

NORMAN G. MEADE.

The repair shop of a manufacturing plant or electric railway plant should have at hand suitable stands or "horses" for holding armatures during the winding process. If the armature is small, short stands may be mounted on a work-bench.

When an armature comes in to be repaired, carefully caliper its diameter outside of the bands and the winding. Observe particularly the shape of the ends. As the workman proceeds to tear apart the armature, he should note the size of wire, style of winding, number of coils, convolutions per coil, number of layers, style of winding, etc. All such data

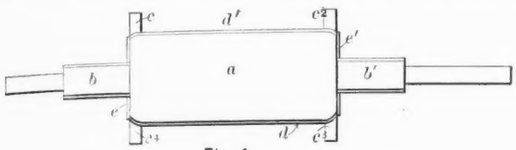


Fig. 1

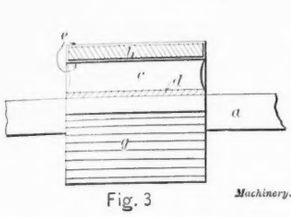


Fig. 3

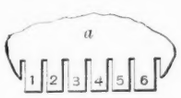


Fig. 2

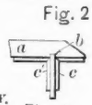


Fig. 4

Machinery, N.Y.

should enter a notebook, as this information will be of future value. It is well to head the entry with the name of the machine, horse-power, voltage and current, speed and serial number of the armature.

The first step in unwinding an armature is to unsolder the leads and remove the commutator. Then cut off the bands and remove the wire. If the coils are of the formed type, laid in slots, raise the upper half around the entire circumference, and remove the coils, in the reverse order to that in which they were put in. After the core is entirely stripped of winding and insulation, it is ready to re-insulate.

Fig. 1 is a sectional view of a smooth-core drum armature insulated ready for winding. In the figure, *a* is the bore; *b* and *b'* the ends of shaft covered as shown; c^1, c^2, c^3 and c^4 are fiber pegs for separating the coils; *d* and *d'* insulation on core, and *e* and *e'* insulating end disks.

Fig. 2 shows the manner of notching the core-insulation to

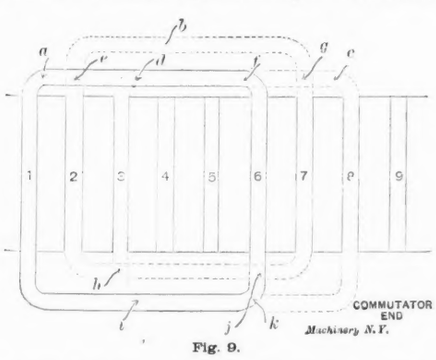


Fig. 9.

fit between the fiber pegs. Flexible micanite 1-32 inch in thickness, and held in place temporarily by a few turns of "flax," forms an excellent insulation. A ring armature, partially in section, is shown in Fig. 3. The shaft, *a*, pressed into the hub, *d*, carries the spider, to which is attached the ring, *b*. One wing of the spider is shown at *c*. A flexible micanite insulation, *e*, covering the outside, inside and ends of ring, is held in place by a tight wrapping of cotton tape, as shown at *g*. The wings of the spider must be insulated. This can be done conveniently, as shown in Fig. 4, which shows a sectional end view of an armature, *a* being the armature ring, *b* the spider wing, and *c* and *c'* triangular-shaped pieces of micanite extending the length of the wing. The triangular pieces are retained in position by the wrapping of cotton tape.

A section of a slotted armature is shown in Fig. 5. Here *a* is the end in section; *b* and *b'* are slots not yet insulated; *c* is a hard-wood or fiber block the length of the slot and slightly narrower; *d* is micanite insulation driven in place by the block, *c*; *e* is a slot insulated ready for the coil; *f* and *f'* are armature coils; *h* is the insulation between the coils; and *i* and i^1 the slot insulation trimmed flush with core *a*. The micanite is cut into strips of the required size, and folded over the block, *c*, to form troughs, as shown.

Another form of slot coming generally into use is shown in Fig. 6, in which *a* is the end of armature; *b* and *b'* V-shaped slots cut for receiving the wood retaining-strip, *e*; *c* and *c'* coils in the slot, with insulation, *d*, between them.

Fig. 7 is an end view of an armature partially in section. This view illustrates the winding process with a form of coil in common use. In the figure, *a* is the shaft; *b* the end of the armature; *c*, a piece of sheet brass the length of the slot and about 4 inches wide; 1, 2, 3, 4, 5, 6, 7 and 8 show the coils with one-half free and one-half in slots; 9, 10, 11, 12, 13, 14, 15 and 16 show one-half of the coil in cross-section. Proceeding to wind an armature of the type shown in Fig. 7, the first process is to insulate the slots in the manner already described, then drive one-half of the coil into place, continuing around the armature, thus filling half of each slot. The armature will then appear as shown. Fig. 8 is a piece of vulcanized fiber, shaped for driving coils into slots. In a four-pole ma-

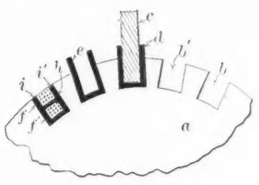


Fig. 5

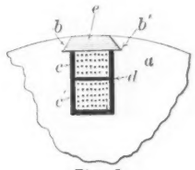


Fig. 6

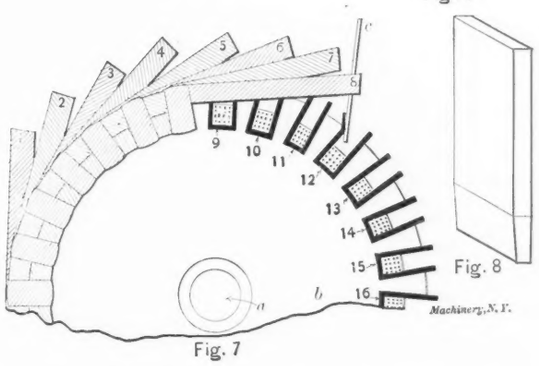


Fig. 7

Fig. 8

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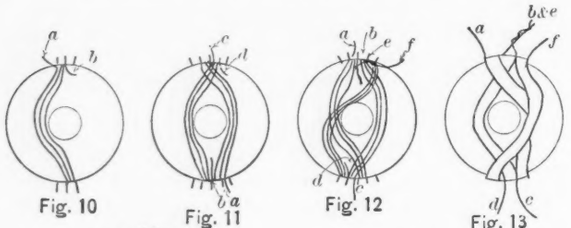
chine each coil will have a pitch of 90 degrees, that is, it will cover one-fourth of the periphery of the armature. The coils slip into the slots easily, with the exception of those on the last quarter. Beginning at a point three-fourths of the distance around the armature from the first coil, the outer half of the coils that have been laid in, will lap over the empty slots. At this point a little more labor is involved in getting the coils into their respective places.

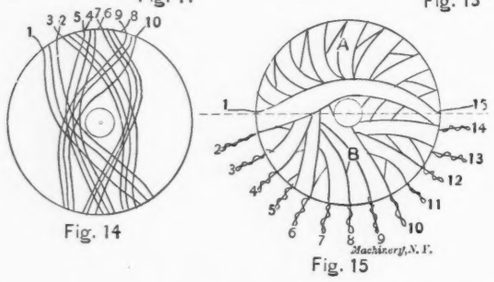
Having completed the first process, start at any point to drive the outer half of the coils into slots. Hold the piece of brass, *c*, before referred to, in the left hand and slip it into the position shown. In this way it guides the coil, 8, into the slot. With a mallet and the tool shown in Fig. 8, drive the coil snugly into place. Continue with each coil in like manner until all have been driven into their proper positions.

In Fig. 9, the periphery of the armature, *A*, is supposed to be laid out flat. In the figure, *a*, *b* and *c* are coils of the oblong type, which form a chordal winding. It will be seen that the coils are staggered, that is, the projecting ends alternate backward and forward. With this style of winding, the ends of the armature core must be well insulated. The coils, if not pounded into shape with a mallet, will interfere at *d*, *e*, *f*, *g*, *h*, *i*, *j* and *k*. The coil, *a*, extends from slots 1 to 6; *b* from 2 to 7, and *c* from 3 to 8. No specific directions can be given here for shaping these coils, as no two makes of armatures

are alike. By noting carefully the shape of the original coil, it will be an easy matter to form the new one. The winding is executed in a manner similar to the formed-coil winding previously described.

Taking up the subject of smooth-core drum armatures, let us study Figs. 10 to 15 inclusive, which illustrate some common types of winding. Starting with Fig. 10, we will assume each coil, for the sake of simplicity, to be one layer deep and





three convolutions in width. Stand facing the commutator end of the armature, and tie the end of wire *a* to the fiber peg. Pass the wire downward over the end of the armature core and between the two pegs, diametrically opposite to the starting point. Turn the armature over and draw the wire tightly along its surface to the back end. Carry the wire around the shaft, on the side opposite to that followed on the front end, and through the pegs back to the starting point, having in the meantime turned the armature over to its original position. It is convenient to have the reel of wire suspended over

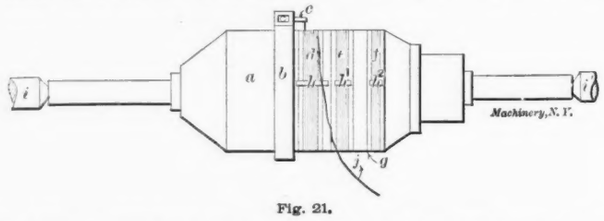


Fig. 21.

the workman's head, so that the wire will pay off freely. Cut the wire from the reel, leaving end *b*. The ends must be long enough to be soldered into the commutator.

Now turn the armature over and begin the second coil to the right of the first one. This will bring the second coil to the left of the first one at the bottom side, as shown in Fig. 11. The ends *c* and *d* are left for connecting to the commutator, as in the first instance. To commence the third coil, turn the armature over again and start at the right of the second coil, Fig. 12, twisting the end *e* around end *b*. Proceed in this

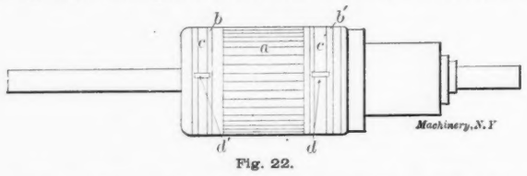
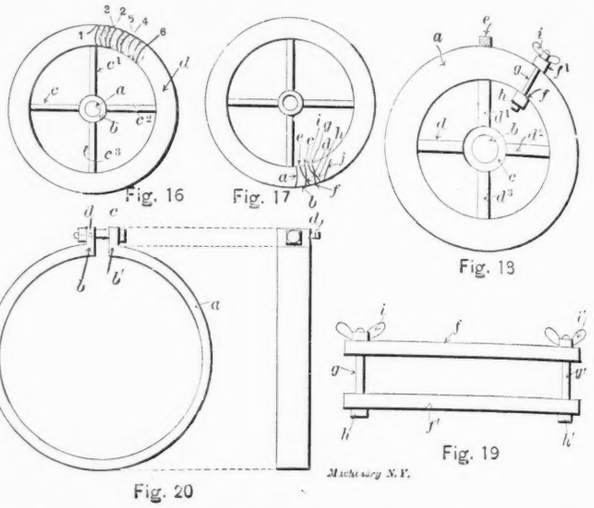


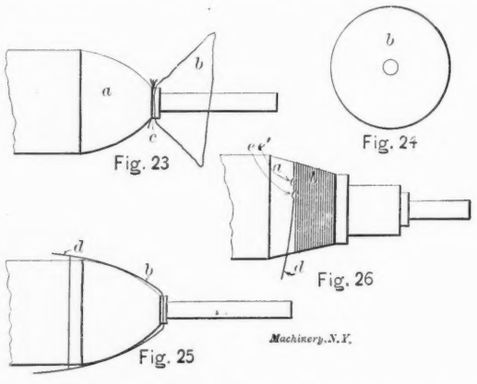
Fig. 22.

manner until all the coils are wound. Fig. 13 gives an idea of the appearance of the armature end after three coils have been wound. It will be seen that every second space between the pegs has two ends. The inner end of the first coil is connected to the outer end of the third coil, there being a blank coil between the two, thus forming a closed or re-entrant winding. Any number of layers or convolutions may be used in this winding. Fig. 14 shows a similar winding, that can be used for two layers or a multiple of two. The only difference is that the second coil is commenced at the ending of the third, and so on until every space is filled, as shown in Fig. 15. If the winding when completed is to be four layers deep, the coils from 1 to 15 inclusive will have two layers, and the remaining coils to be wound will also have the same number. The half, *A*, of the armature will have no ends at this stage of the winding. The second set of coils, whose ends protrude in the half, *A*, commences at 15 and extends around to 1. The outer end of one coil joins to the inside of the



next. This is clearly shown in Fig. 14, where end 3 of the second coil joins end 2 of the first coil, and so on. It is unnecessary to cut the wire, as it can be left in loops as shown at 1, 2, 3, etc., in Fig. 15.

We will now turn to smooth-core ring armatures. In Fig. 16, *a* is the shaft and *b* the spider hub, to which are attached the wings, *c*, c^1, c^2 and c^3, bearing the ring, *d*. The winding forms a continuous spiral, the end 2 of coil 1 being attached to end 3 of coil 2, etc. As the space on the inner surface of the armature is less than that of the periphery, the winding will have a greater number of layers inside than on the outer surface. An exaggerated view of a method of winding to accomplish such a result is shown in Fig. 17. The wire starts at *a*, then passes around the ring and comes to the front at *b*, passes under at *c*, and returns at *d*. It is then carried under at *e*, between *a* and *c*, starting the second layer on the



inner surface. From *f*, the wire goes to *g*, and back to *h*, thence to *i*, between *c* and *g*, coming back at *j*. Thus we have five convolutions and one layer on the outer surface, and two layers—one of three and one of two convolutions—on the inner surface.

In Fig. 18 the application of the clamp shown in Fig. 19 is given. This clamp consists of two wood pieces, *f* and *f'*, and two bolts, *g* and *g'*, with heads, *h* and *h'*, and thumb nuts, *i* and *i'*. This clamp serves to hold the wire of each coil in position while winding, and is moved around as fast as a coil is completed. Referring again to Fig. 18, the wood piece, *e*, is used for filling the gap in the outer surface of the winding caused by the spider wings, *d*, d^1, d^2, d^3. It is made equal in width to the wing, and of the same depth as the winding. In bal-

ancing an armature one or more of these strips may be removed and lead strips wound in tape substituted.

All armatures must be carefully balanced, which can be accomplished by several methods, one of which has just been mentioned. If the air-gap of the machine has clearance enough, solder may be flowed onto the bands. With slotted armatures, some makers bore holes in the core on the heavier side, thus equalizing the weight. Another method is to bind a piece of sheet lead on the front end of the armature over the lead wires, by a tape and cord.

As no definite rule can be given for soldering lead wires into a commutator, only a few suggestions will be offered. Tin the slots in the segments and the armature leads before soldering.

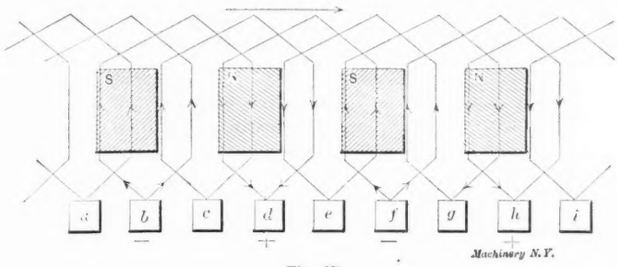


Fig. 27.

See that the slot is flowed full of solder. Do not use acid for flux on small wire, as corrosion will take place. Be extremely careful that no drops of solder lodge between or back of the segments. Each coil should be tested for grounds as it is wound, and to make sure that the right ends are connected. A convenient testing arrangement was explained in a previous article entitled "Commutators," and can be applied to this purpose. A magneto bell, a galvanometer or a Wheatstone bridge may be used for testing purposes.

Fig. 20 gives two views of a clamp that is used in winding armature bands, *a* being a hoop of band-iron, with its inside diameter equal to the outside diameter of the armature. The ends *b* and *b'* are bent up as shown, and bored to receive a clamping bolt, *c*. A pin, *d*, is attached to the end, *b*, for fastening the binding wire.

Fig. 21 shows clearly the practical application of the clamp. In this sketch, *a* is the armature; *b*, the clamp; *c*, the pin; *d*, the band being wound; *e* and *f*, finished bands; *g*, mica insulation under bands; *h*, h^1 and h^2, brass clips for holding the bands together. The lathe centers are shown at *i* and *i'*. The end of the brass wire *j* passes through the fiber friction blocks in the toolpost.

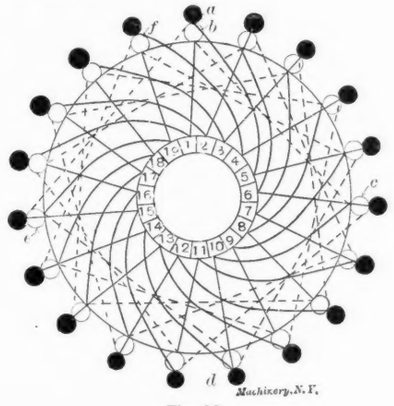


Fig. 28.

The manner of winding an armature is essentially the same as that of a commutator, which has already been fully described in an article under the latter head.

A completed armature, with slots of the type shown in Fig. 6, is illustrated in Fig. 22. The core, with wood retaining strips driven into slots, is shown at *a*. Mica strips *b* and *b'*, under bands *c c*, are for the usual insulating purpose. Brass chips *d* and *d'* are attached in the regular manner. Armatures with wood retaining-strips in slots require but two bands, which are wound on the coil ends that project beyond the core.

A method of protecting the ends of a surface-wound drum armature is illustrated in Figs. 23, 24, 25 and 26. A canvas disk, *b*, Fig. 24, is tied by a cord, *c*, to the end of armature, *a*, Fig. 23. The disk is then drawn over the end and tied temporarily with a cord, *d*, as in Fig. 25. The armature band serves to hold this hood in place permanently.

An effective manner of finishing the commutator end of an armature is illustrated in Fig. 26. The end, *a*, is wound tightly with cord about ¼ inch in diameter, as shown at *b*. Two loops of string, *e* and *e'*, are caught under the last two or three turns of cord and the end, *d*, is passed through them, after which the loops are drawn up, the ends trimmed off and the cord cut close to the last loop. After the armature is completed, it should be given a thorough coating of shellac and placed in an oven. When fully dried out, put on two even coats of P. & B. compound, which gives it a good black and waterproof finish.

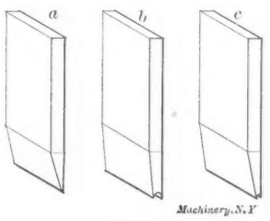


Fig. 29.

As a complete description of the numerous styles of connecting up armatures is beyond the scope of this article, only a few of the common types will be taken up. For further information on this subject the reader is referred to one of the many text-books on dynamo-electric machinery.

Fig. 27 illustrates, graphically, a lap-winding. The poles of the machine are represented at *S*, *N*, *S*, *N*, and the commutator segments are indicated by the squares *a*, *b*, *c*, etc. We will take, for example, the coil starting at *b*. The conductor passes over the left face of the *S* pole, and then returns over the middle of the *N* pole, to the adjoining segment, *c*. This series of loops is continued around the armature, forming a complete circuit. The large arrow indicates the direction in which the conductors are moving, and the small arrow-heads on the wires show the disposition of the current.

A diagram of a hand-wound armature, with a wave winding, is shown in Fig. 28. To avoid complications, nineteen coils only are shown. This type of armature is extensively used by the Shaw Electric Crane Company. The small white circles around the circumference of the armature, as at *b*, represent the first layer of wire; the black circles, at *a*, show the outer layer. The dotted lines indicate the conductors passing over the back end of the armature. Starting at the commutator segment 1, the conductor goes to *b*, then to *c*, and connects to segment 10. Here we start a new coil, going to *d*, then to *e*, and connecting to segment 19, one remove from the starting point. The third coil starts here and leads to *f*, and so on until one layer is completed, when one-quarter of the circumference of the armature on each side will have ends protruding, that is, the first quarter will have leads, the second will be blank, the third will have leads again, and the fourth will be blank. Start the second layer at the end of the first one. When the winding is completed, each slot will have two ends, as shown in the figure. An armature with formed coils can be connected in a like manner.

A few handy tools can be made from fiber; they are shown at *a*, *b* and *c*, in Fig. 29. These tools are used for driving the wires into place, etc.

Rewinding an armature requires great care and neatness. The dimensions and shape of the original winding should always be closely followed, as an armature which is but a fraction of an inch too large is useless.

* * *

Referring to the item "Cast Iron Sinks" in the November issue, Mr. Robert Grimshaw, Hanover, Germany, writes: "'Cast Iron Sinks' is at any rate true, but how about the sign in the next window of the same plumber's shop, 'Copper Floats?' If we believed that, literally, we would believe anything."

TOOL MAKING.—13.

MILLING MACHINE CUTTERS.

E. R. MARKHAM.

Milling machine cutters are either made solid or with inserted teeth. Those 6 inches and under in diameter are usually made solid, but in most shops those over 6 inches are made with inserted teeth, though in some it is considered good practice to make them solid up to 8 inches diameter. Certain forms of cutters, much larger than the size mentioned, must be made solid, and it is advisable when hardening these to employ a method that will insure the desired degree of hardness with little or no risk of cracking.

When selecting steel for cutters first price should never be a consideration provided the higher-priced article is the best for the purpose; however, for most purposes, steel can be procured for a reasonable price that answers as well as some of the more costly ones. There are several alloy steels on the market, made especially for cutters of this class, which work nicely; they will stand higher speeds and run longer between grindings than steel made for all-around work. Most of these, however, are rather "cranky," and require very careful treatment in the fire and hardening bath, and should not be used unless the hardener is thoroughly experienced and understands handling "special" steels. If conditions are such that they can be worked successfully they prove very satisfactory and their use is to be advocated; on the other hand, if conditions are not favorable they give best satisfaction "when left alone."

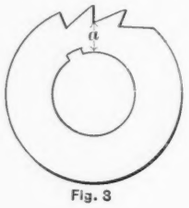


Fig. 3

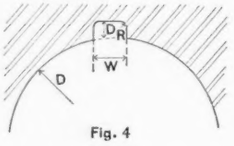


Fig. 4

Fig. 1

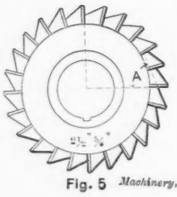


Fig. 5 *Machinery, N.Y.*

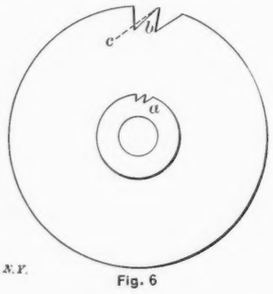


Fig. 6

It often happens that a cutter is desired which calls for stock larger than any on hand, and as but little is wanted, and that little right away, it seems advisable to take a piece of the largest available and upset it to a size that will machine to the desired dimensions. Right here we meet a whole "heap" of trouble. When steel is made, the drawing by rolling and hammering is all in one direction—namely, in the direction of the length of the bar. Now if the steel is upset *somewhat*, the "grain" is in all directions, and the adhesion between the molecules is weakened perceptibly; and when the steel is hardened it is liable, and in fact almost sure, to go to pieces, or at least crack in all directions. But if the piece of steel is upset enough to overcome this difficulty the trouble mentioned will not be experienced. As an illustration, the writer at one time saw a cutter 6 inches in diameter, stock for which had been upset from 5-inch steel. The upsetting was done on an anvil, by means of hand sledges, and the cutter was finished to size and shape. When hardened it went to pieces, the cracks running from center to circumference in irregular lines. Another cutter was made at the writer's suggestion from a piece of 4-inch stock upset under a steam hammer. The hardening was done by the same man, in as nearly as possible the same manner as the first one. It came out all right, as have a number of others made since then. Of course this can be carried to an extreme, but unless stock is to be upset sufficiently to change the direction of the "grain" steel that is to be hardened should never be upset at all.

As has been stated a number of times in these articles, there is a decarbonized portion at the surface of all tool steel as it comes from the steel mill. Stock must be selected sufficiently large to allow removing this surface when the cutter is machined to size. When upsetting steel it is best to allow more than would be necessary when cutting from a bar of the right size; for the steel at the circumference, not having anything to restrain it, flows under the blows of the hammer more readily than any other portion, and as this is the very portion where strength is required, sufficient stock should be removed to cut away this portion. Of course we could hammer around the circumference with light blows, but the effect would not be that desired, as we might again change the grain. The writer's experience has convinced him that while it does very well to occasionally hammer around the circumference when flattening out, there should be no heavy blows—if any at all—after the final blows of upsetting.

When forging large pieces of steel it is necessary to strike blows sufficiently heavy to make the steel flow as uniformly as possible. Light blows on the surface of a large piece of steel have the effect of drawing a portion of the surface away from the stock underneath, and this will break away when the contraction incident to hardening takes place, or if not then, it is sure to do so when in use. On the other hand, extremely heavy blows on small sections crush the grain, thus spoiling the steel.

Steel for cutters should be annealed after a hole has been machined in the center, and the blank blocked out somewhere near to shape. The object in annealing is not necessarily to make the steel soft, but to remove the strains set up in the steel by the operations of rolling and hammering in the steel mill, or forging in the blacksmith shop. If a piece of steel is annealed ever so thoroughly when solid and a hole then machined in it, strains are liable to manifest themselves in a very unpleasant manner when the piece is hardened. If, however, the piece when annealed is, as near as is practicable, of the same form as when hardened, all harmful tendencies will be overcome by the annealing process. The hole made must be somewhat smaller than finish size—say 1-16 inch—and the diameter of the cutter must be somewhat large. All scale on the surface must be removed and the steel annealed. There are several methods of annealing, probably the most satisfactory being the packing in a hardening box with powdered charcoal, placing in the furnace and running until the steel is uniformly heated to a low red. The annealing heat should be as high as the hardening heat, to overcome strains; but never high enough to open the grain. The steel should not remain *red* hot any longer than is necessary but it should be a long time in cooling off *from* a red heat. An excellent method which can be practiced in almost any shop consists in placing hot ashes in an iron box—or other receptacle—to the depth of 2 or 3 inches. On this place a piece of board and after the steel has been uniformly heated to a *low* red lay it on the board with another board over it and bury the whole with hot ashes. Pieces annealed by this method are not likely to be over-annealed, and as they cool below a red more quickly than with the former-mentioned method, and yet cool from a red to a temperature of 300 or 400 degrees F. very slowly, excellent results are nearly always obtained, provided the heat was uniform.

A common practice is to heat red hot and place in a box of cold ashes, or lime. Ashes and lime should be well heated before the steel is placed in them, which is done by heating a piece of iron, or scrap steel, red hot, placing in the ashes or lime and allowing it to remain while the steel to be annealed is being heated. It is then removed and the steel put in its place. It must always be borne in mind that if the red-hot metal is brought in contact with cold or damp substances, the heat is extracted from it rapidly, thus causing it to harden somewhat. Moisture, even though it be warm, must be avoided in anything that red-hot steel is buried in. For steam, if projected against red-hot steel, under certain conditions, would cause it to harden. For this reason never bury steel in damp ashes or lime.

After annealing, place the blank in the lathe chuck and machine the hole to desired size. In many shops it is the custom to make the hole about .005 inch smaller than the milling machine arbor on which it is to be used, and after

hardening it is ground to size with the internal grinding attachment provided with all universal grinding machines. In shops where there is no appliance for internal grinding, the blanks are very carefully annealed to remove, as far as possible, all strains incident to working in the steel mill or forge shop, then the hole is machined .0015 or .002 inch smaller than the arbor and is lapped to size after hardening. When I say arbor I do not wish to be understood as advocating working to the milling machine arbor, as all holes should be ground to a standard gage, a hardened plug gage or a standard disk. When the hole is machined to the required size the blank is placed on a mandrel and machined to the desired length and diameter.

To facilitate grinding or lapping the hole to size after hardening it is advisable when machining it to recess it, as shown in Fig. 1, leaving a bearing portion at each end. For the same reason it is generally considered best to cut away a portion at each end, as shown at *a*, Fig. 2, thus saving time

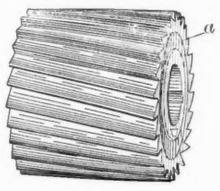


Fig. 2.

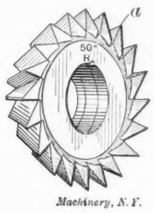


Fig. 7.

when grinding the ends. The operator should never leave *sharp* corners when recessing the holes, or cutting in at the ends, as sharp corners are likely to cause cracks when the steel is hardened.

The number of teeth in a milling machine cutter is a subject that has been debated for years, and one on which mechanics fail to agree, as conditions vary in different shops. Most manufacturers, I think, are agreed that reasonably coarse teeth work better than fine, for with the latter it is necessary to feed very slowly, as the spaces between the teeth fill with chips, thus causing the teeth to break. The following, from Brown & Sharpe's book, "Construction and Use of Milling Machines," seems to express the opinion of most men whom the writer has met who have had a broad experience in milling machine work: "Of late years mills have been made with coarser teeth than formerly, the advantages being more room for the chips and less friction between the teeth and the work. When the teeth are so fine that the mill drags, or where the stock is powdered, the mill heats quickly and does not cut freely."

When cutters are used on hand milling machines it is generally necessary to make the teeth somewhat firmer than when they are used on power milling machines.

It is considered best practice in most shops to make cutters of as small diameter as possible consistent with economy. By this is meant they should be large enough to allow of working over two or three times if this is practicable. Speaking from a theoretical standpoint each tooth should do its proportionate amount of cutting and the feed can be graduated to correspond with the number of cutting edges. But experience has proven that it is almost impossible to get a cutter on a milling machine arbor and have it run true enough to insure all the teeth cutting. And when but comparatively few teeth are doing any work it is necessary to feed as fine as when using a smaller cutter, and the speed of the cutter is necessarily slower, so the progress made is not as great.

In designing cutters, however, they must be of a size that insures sufficient strength at the point between the hole and the bottom of the cut between the teeth. The distance necessary to insure the proper amount of strength depends somewhat on the nature of the work to be done with the cutter. However, for general use there should be at least $\frac{3}{8}$ inch at this point, as shown at *a*, Fig. 3. If milling cutters are hardened by the process known as "pack hardening" this space may be made somewhat less, as the steel will not be as brittle as if hardened by the ordinary methods.

To prevent the cutter turning on the milling machine arbor a keyway must be provided. In order that cutters having holes of given diameter may have a given size of key, manufacturers of milling machine cutters have adopted standard sizes of keyways. Fig. 4 represents a sectional view of a portion of a cutter showing a keyway, and herewith is given a table of sizes. The various dimensions are designated by letters, as will be readily seen. The drawing and table are taken from Brown & Sharpe's catalogue and apply to cutters furnished by them:

Diameter (D) of Hole.	Width (W) of Keyway.	Depth (D) of Keyway.	Radius (R).
3-8″ to 9-16″	3-32″	3-64″	.020″
5-8 to 7-8	1-8	1-16	.030
15-16 to 1 1-8	5-32	5-64	.035
1 3-16 to 1 3-8	3-16	3-32	.040
1 7-16 to 1 3-4	1-4	1-8	.050
1 13-16 to 2	5-16	5-32	.060
2 1-16 to 2 1-2	3-8	3-16	.060
2 9-16 to 3	7-16	3-16	.060

Cutters used for cutting narrow surfaces have their teeth cut straight. In some shops all cutters used in cutting surfaces wider than $\frac{1}{2}$ inch have their teeth cut spirally; in others they are cut straight unless $\frac{3}{4}$ inch or more in width.

The shape of the tooth plays a very important part in the way the cutter works. If the tooth is slender it springs into the work when heavy cuts are taken, as explained in the article in the December issue. It has been found by experiment that a cutter tooth having its face and back at an angle of about 50 degrees, as shown at *A*, Fig. 5, insures a strong tooth and sufficient depth of groove between teeth for chips. To produce a tooth of the proper shape for cutters of various sizes it is obvious that angular milling cutters of various angles are necessary. A cutter that would produce a tooth of the desired shape on a mill 2 inches in diameter would not

Fig. 9

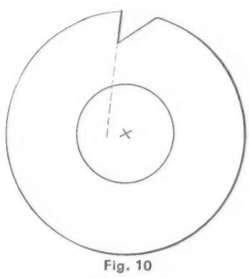


Fig. 10

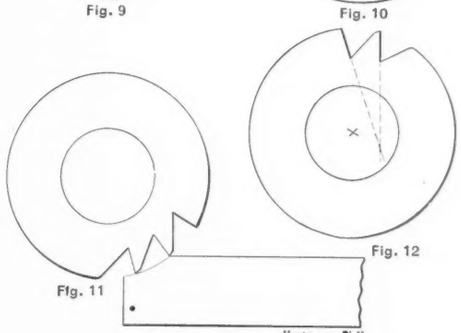


Fig. 11

Fig. 12

answer when producing teeth on one 6 inches in diameter. This is shown in Fig. 6, where *a* represents a portion of a cutter of 2 inches diameter whose teeth are produced with a cutter of 60 degrees angle, and *b* a tooth produced by the same cutter on one 6 inches in diameter. The dotted line *c* shows the back of tooth if it and the face were at angle of 50 degrees. The tooth should be left about 1-32 inch broad across the top. The exact measurement cannot be stated arbitrarily; for small mills and light cuts .02 inch answers nicely, while for large mills which are to take heavy cuts it is necessary to leave them .04 inch across.

The angular cutter for producing the teeth should have the corners of the teeth, *a*, Fig. 7, slightly rounded rather than sharp. The amount of round need be but slight, but it makes a stronger cutter when the groovers are cut a trifle rounding in the bottom and it also reduces the tendency to crack when the cutter is hardened, sharp corners being an invitation to crack.

Milling Cutters with Spiral Teeth.

It is necessary when cutting mills of this type to use an angular milling cutter—having a slight angle on one side and the other side of a shape that will form an included angle of the form of the groove to be cut. The side which cuts the face of the tooth is generally made of an angle of 12 degrees, as shown in Fig. 8; while the opposite side may be either 40, 48 or 53 degrees, according to the size of the cutters to be cut.

When rigging up the universal milling machine if the angular milling cutter is set as shown in Fig. 8, so the distance *A* is about 1-12 the diameter, the face of the tooth cut by the side having an angle of 12 degrees will be nearly right for cutters of the usual proportions. The setting of the angular mill for the location of tooth must be made before turning the spiral bed to the desired angle of spiral. For cutting spiral milling cutters choose a helix that will produce the desired angle on the cutting edge. This varies, but for general purposes an angle of about 15 to 20 degrees with a plane passing through the axis of the cutter, gives good results The helix may be either right- or left-hand, as desired, but unless the arbor is supported at the outer end it is best to make it of a hand that will force the arbor into the hole in the spindle rather than tend to draw it out. Then again it is better to have the thrust caused by cutting action against the solid shoulder of the spindle at the outer end of bearing rather than against the take-up nuts on the inside end of bearing.

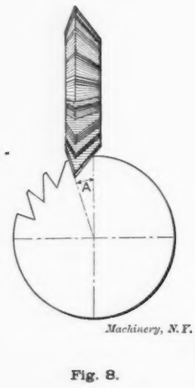


Fig. 8.

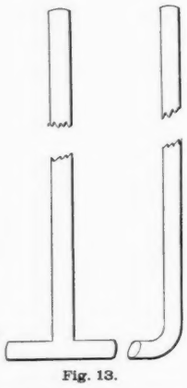


Fig. 13.

If two cutters are to be used on the same arbor it is a good plan to cut one with a right-hand spiral and the other with a left. In this manner the strain is equalized. This might, however, be objected to by some, on the ground that it would be more difficult to grind two cutters whose teeth were of opposite spirals to exact size than if they were of the same hand; but this need be no objection if reasonable care is exercised when grinding.

When the mill is to be used for the general run of work the cutting face of teeth is usually made radial and it is safe to say that as a rule the face of the teeth should be radial, as shown in Fig. 9. For certain classes of work it is necessary to depart from this custom. When the cutter is to be used for sinking a slot into a piece of metal it works better if the teeth are cut somewhat hooking, as shown in Fig. 10. When a mill is to be run onto the work, as shown in Fig. 11, there is less liability of its being drawn onto the stock and catching if the teeth are given a negative rake, i. e., cut ahead of the center, as shown in Fig. 12. While the generality of shops make cutter teeth radial, there are large manufacturing concerns which make most of their cutters with their faces receding, as shown in Fig. 10. However, to prevent chattering it is necessary to use heavy, stiff milling machines and to provide arbors somewhat larger than when cutters with radial teeth are used. Teeth cut as shown in Fig. 10 cut more readily than those cut radial.

As previously stated, no arbitrary rule can be given for the number of teeth for a cutter of a given size. Yet it is necessary to have a standard—if it can be so called—which may be departed from as occasion requires and the following table was in use in a shop where the writer was in charge and seemed very satisfactory:

Diameter of Cutter.	No. of Cutting Edges.	Diameter of Cutter.	No. of Cutting Edges.
½"	6	2½"	20
¾	8	3	24
1	10 or 12	3½	26
1¼	14	4	28
1½	16	5	30
2	18	6	32

If reference is made to engineers' hand books for information it will be found that various authorities are cited and that in some cases the pitch advocated by these writers differs greatly, showing that the distance apart of the teeth to insure best results depends on the class of work and the machine employed when doing it, as well as on the ideas of the designer in charge.

If the angular cutter used when cutting the teeth was in proper condition it should leave the surfaces of the teeth very smooth. The size and distinguishing marks should be stamped on the cutter, and then it is ready for hardening. If possible use the method known as pack hardening, as all danger of cracking is eliminated, and the cutter can be run much faster than when hardened by the ordinary methods; and even at the higher speed it will stand up longer between grindings.

If the cutter is to be pack-hardened and is made of steel containing more than 1¼ per cent carbon, use charred hoofs rather than charred leather as packing material. Do not use any wood charcoal, but simply charred hoofs. This method was described in a previous article. If necessary to harden by the ordinary methods, best results when heating are obtained by the use of some form of muffle furnace. Of these there are several forms on the market, any of which give good results. If only an open fire is available excellent results may be obtained if the operator will use the proper amount of care when heating. Have a large, high fire so as to get the cutter well up from the blast inlet. Use a *new* fire of charcoal, but have the coal well lighted so the heat will be uniform around the cutter. If an old fire (one that is nearly burned out) is used considerable blast will be needed to keep it alive and the air from the blast striking the heated cutter will cause innumerable cracks in the lighter portions of the teeth.

The cutter should be heated as rapidly as possible and the heat should be uniform. Do not attempt to force the fire, or the teeth, being lighter than the balance of the cutter, will heat more rapidly and so become overheated before the center is hot enough. The heat must be uniform and no higher than necessary to produce the desired result. A piece having projecting portions, like the teeth of a cutter, need not be heated as hot as a solid piece of the same size.

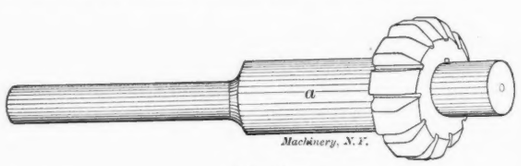


Fig. 14.

Should the cutter, through carelessness, become overheated, do not, as is the custom with some hardeners, hold it exposed to the air until it has apparently cooled to the desired temperature, and then plunge in the hardening bath; the grain of the steel always shows the effect of the highest heat it receives until it cools, and is again heated. Then again the surface cooling more rapidly than the internal portions would apparently be about right, while the stock nearer the middle would be much hotter; in other words it would be unevenly heated, and would contract unevenly and be very apt to crack. An overheated piece that is not *burned*, may be laid to one side and allowed to cool off, then reheated and hardened. If allowed to cool to a low red from a high heat and dipped, and it did not crack, the grain would be open and the steel weak, and it would crumble when in use.

Care must be exercised when dipping milling machine cutters in the hardening bath that the heat will be taken from the cutter by the bath uniformly. For this reason I prefer a bath having perforated pipes coming up from the

sides, by means of which jets of liquid are projected against the teeth uniformly at all points. If such a bath is not at hand, the cutter must be worked around in the liquid quite rapidly, to insure uniformity of results. Cold baths should not be used for this class of work, as they cause much trouble; the writer prefers a bath of brine which is of a temperature of about 70 degrees F.

As previously stated, all cutter blanks should be annealed after having a hole drilled through them and the outer surface of the stock removed, otherwise trouble may be experienced when hardening, especially if the cutter is to be of an irregular shape. Unless the cutter blank is annealed while in a form somewhere near that of the finished cutter, the strains in the steel will manifest themselves by irregular contraction when the cutter is cooling in the bath. To overcome this tendency to crack from unequal contraction, the cutter is slowly heated to a low red, removed from the fire and allowed to cool off until all traces of red have disappeared, when it may be placed in the fire again and reheated to the proper hardening heat and dipped in the bath. As the teeth are the only portion of the cutter which need be hard, the cutter may be removed from the bath as soon as it is hard and immediately placed in a tank of oil and allowed to remain until cool. Allow the contents of the bath access to all parts of the cutter. Hold the cutter in a manner that permits the liquid to circulate through the hole freely. A wire bent in the form shown in Fig. 13 answers nicely. The usual forms of tongs would not answer, as a portion of the outer surface would be covered by one of the jaws, thus causing unequal contraction.

After hardening, the cutter is reheated sufficiently to overcome any tendency to crack from internal strains due to hardening. It is then brightened, and the temper drawn to a light straw color, by placing on a plug of the form shown in Fig. 14. Do not have the portion marked *a* fill the hole in the cutter. Before placing the cutter on this plug it is heated somewhat, as the extreme heat in the plug if brought in contact with the walls of the hole in the cold cutter would cause rapid expansion, and perhaps cracking. While on the plug the cutter is held over the fire and the outer portion heated thereby, and when the proper temper color is visible, it is placed in warm oil and allowed to cool to the temperature of the oil. When a number of cutters are to be tempered, best results are obtained by heating in a kettle of oil, gaging the heat by a thermometer, 430 degrees being equivalent to a light straw color. If the cutter is hardened at the proper heat—the refining heat—the temper need not be drawn as low as when higher heats are employed.

Before grinding the hole in the cutter to size, remove all scale and gum, as this tends to glaze the wheel. The hole should be ground to a standard. The outer end of the cutter may be ground before removing it from the chuck, which insures the end being true with the hole. Then remove the cutter from the chuck, and hold the cutter on an expanding plug, with the end that has been ground against the faceplate provided for such purposes, and grind the opposite end as shown in Fig. 15.

It is customary in some shops to simply grind the walls of the hole while the cutter is held in the chuck, the ends being ground while the cutter is held on a mandrel like that in Fig. 16. By this method the ends must be parallel. However, if reasonable care is exercised regarding the condition of the faceplate and freedom from dirt, excellent results are obtained by the first-named method.

After grinding to length, the teeth are given the necessary clearance for cutting. A suitable wheel should be used, free from glaze to avoid any possibility of softening the cutter teeth by the heat generated by friction between a glazed wheel and the cutting tooth. A machine shop having even a few milling machines should be provided with suitable means of grinding the cutters. A dull mill wears away very rapidly and produces very unsatisfactory work and it pays to exercise care as to the condition of the teeth.

The wheel used on the cutter grinder should be as large as can be conveniently used without danger of striking the adjoining tooth. It should be the proper grade and number of emery (if an emery wheel). It is a mistake to use a hard wheel; it should be soft enough to allow of being easily scratched with a pointed instrument. The size of emery used in making the wheel cannot be definitely stated, as the class of work must, in a measure, determine this, and wheels made of a certain size emery (or other abrasive material) by one manufacturer do not agree as regards results with wheels of the same size emery, and of the same designated grade, made by another. However, it is not generally best to use an emery coarser than 60 or finer than 90. A wheel of the proper grade should be about ¼-inch wide. If the wheels at hand are thicker than this, cut a corner off as in Fig. 17, until the face does not exceed ¼-inch width. If necessary to use a wheel that is too hard, the face should be narrower than the measurement given above; if very hard, reduce to ⅛-inch or even less. A soft wheel should be run faster than a hard one, but as a rule the maximum speed should not exceed 5,000 feet per minute; that is, the circumference of the wheel should travel at the rate of 5,000 feet per minute. This is termed the periphery speed. If the wheel is glazed, remove this by the use of a piece of emery wheel a trifle harder than the one being used. This produces an open appearance on the surface of the wheel.

For most purposes an angle of clearance of 3 degrees answers nicely; that is, 87 degrees from a radial line as shown in Fig. 18. When grinding for clearance, take light cuts and move the cutter tooth rapidly by the wheel. As so much depends on the emery wheel used for grinding for clearance, it is well to procure wheels of a reputable maker, stating when ordering, the class of work to be done. Their experience in

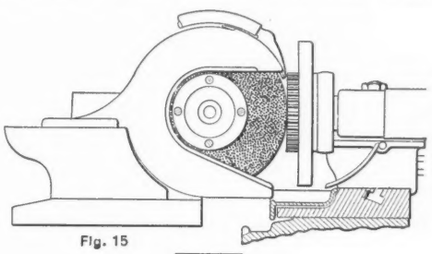


Fig. 15

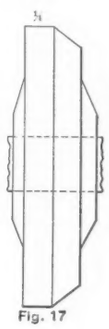


Fig. 17

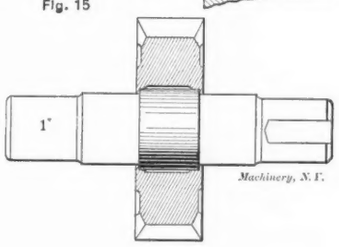


Fig. 16

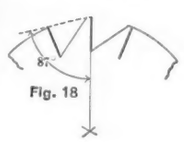


Fig. 18

furnishing wheels for various purposes has taught them exactly what wheel is suitable for the job in hand.

When using mills suitable speeds and feeds must be employed. A 6-inch mill if run at the number of revolutions per minute that would be maximum for a 3-inch, could not stand up on the same work; the periphery speed must be right. When taking light cuts, a mill may be run more rapidly than when taking heavier cuts. When cutting hard metals a slower speed must be used than when machining softer ones. Cutters which are properly "pack hardened" will stand, as a rule, a speed 50 per cent greater than if hardened by ordinary methods. We must, however, have a basis from which to start, and some authorities claim for ordinary grades of machinery steel a speed of 35 feet; for cast iron, 60 feet; and for brass 125 feet, but as all these metals vary in hardness the above figures are only approximate. Cutters stand best when given proper feeds. If the feed is too coarse, the cutting edges are knocked off; if too fine, the cutter dulls owing to the teeth rubbing against the stock. In the ordinary shop there is greater danger of feeds being too fine than too coarse.

In the next article we will conclude the subject of milling machine cutters and take up side milling cutters, milling cutters with inserted teeth, etc.

* * *

If the job of being a foreman were not more difficult than being a mere machine man, it would not pay better.—*Woodworker.*

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IMPORTANCE OF ELEMENTARY PRINCIPLES.

In reviewing the steam turbine patents of the past century for the series upon this subject in the Engineering Edition, it has become evident to the writer that a great many inventors who have wasted their good money on worthless patents would have been far better off if they had invested the same amount in a course of lessons in the principles of physics, heat and steam. A fact that has been demonstrated time and time again is that the reaction of a jet of fluid, such as steam or water, when flowing from a nozzle, is equal and opposite to the impulse due to the momentum of the jet; and it makes no difference whether the jet discharges freely into the atmosphere or whether some obstacle is held in its path. So long as an obstacle is not placed near enough the outlet of the nozzle to choke the discharge, the reaction will remain the same, whether the jet strikes against some stationary object or not.

In spite of this well-known principle, many inventors have taken out patents on devices for turbines of the reaction type in which the jet is made to impinge against stationary projections as the wheel revolves, with a view to giving the wheel a harder push backward than the inventor believed would be the case if the jet flowed freely into the air. The idea appears to be prevalent that if the jet has an opportunity to push against something its effect will be greater.

One of the necessary requisites in a steam turbine is that in some way the speed of rotation shall be reduced, and what has seemed to many inventors to be a plausible method has been that of employing the injector principle for combining the steam with some heavier gas or liquid, with a view to reducing the velocity of the jet and hence the velocity of the wheel.

A turbine on this plan would undoubtedly work, but it would also cost many times more to operate it than its owner would care to pay for. The velocity of the combined jet consisting of steam and the other fluid—water, for example—is given approximately by the formula $V_1 = \frac{V}{W+1}$, where V is the velocity of the steam as it leaves the steam nozzle, and W is the weight of water used for each pound of steam. This formula is derived by the well-known principle that momentum before impact must be equal to momentum after impact. The ability of the steam jet to perform work on the wheel, however, is given by the expression $\frac{V^2}{2G}$ for each pound of steam, and of the water jet $\frac{(W+1)\,V^2}{2\,G}$. We will not attempt to apply these equations here, but the reader can easily perceive that inasmuch as the ability of the jet to do work is measured by the second power of the velocity and only the first power of the weight, the combining of the heavier fluid with the lighter will have the effect of reducing the kinetic energy and so of making the turbine inefficient.

What becomes of the kinetic energy lost in this process? Obviously part of it is converted into pressure and part of it appears as heat energy. The injector affords a striking example of this, where we find that, considered simply as a mechanical machine, without regard to heating the feed water, it will consume some 12 to 15 times as much steam per H. P. hour as a steam engine of the same power would consume.

* * *

THE POSSIBILITIES OF BOG FUEL.

Investigations of bog fuel made by the Insurance Engineering Experiment Station under the direction of Mr. Edward Atkinson apparently demonstrate beyond question that the possible exhaustion of our coal supply need not immediately trouble us, since this country possesses vast quantities of available fuel in its marshes and bogs. The Irish peasants have for generations been making use of peat, which practically forms their sole basis of fuel supply, but the bogs of Ireland differ from those in this country inasmuch as they are composed of moss and other vegetable products only partially decayed, while the larger deposits here are more of the nature of mud. Many failures have resulted from attempting to work the contents of mud bogs into fuel at low cost, and apparently for very simple reasons. The efforts heretofore have been to dry and then compress the fuel, using some other substance as a binding material to overcome its friable nature. This, of course, made necessary a lot of expensive machinery for compressing the briquettes, and required the addition of various foreign materials for the binder. According to Mr. Atkinson's report investigation in Germany disclosed the fact that the carbonaceous contents of these bogs consist of fixed carbon and hydrocarbon, the latter being a very adhesive substance contained in minute vesicles. These vesicles are broken up, which is done very simply by running the mud through a machine resembling a sausage chopper, and the broken hydrocarbon vesicles and their contents become diffused through the mud and act as a binder. Moreover, the mechanical breaking up of the mud mass liberates the water and allows it to evaporate rapidly under ordinary conditions. It is said that briquettes made in this manner contract or condense into a more or less solid form, in some cases increasing in specific gravity to that of the ordinary types of bituminous coal.

Apparently, from Messrs. Atkinson and Norton's reports, there are many opportunities for the development of fuel plants with comparatively small capital, wherever bogs or marshes of the proper constituency exist. Of course, many bogs are not possible sources of profitable fuel supply, and in any case careful investigation should be made before an attempt is made at development. Mr. Atkinson thinks that a plant costing about $2,500 will, as an average, turn out 20 tons of bog fuel per day, or allowing for holidays and storms about 5,000 tons per year. There are many regions now, more or less remote from coal mines, where a cheaper fuel supply would be greatly appreciated, and if such happen to possess supposedly worthless swamps, it may be instead that they have an inexhaustible supply of good fuel at their very doors.

* * *

While high-speed steel is said to make excellent razors, it appears inadvisable to use it for this purpose, if we accept the testimony of one of the members of the Iron and Steel Institute at the recent New York meeting. He said that there had been one curious fact noted in connection with high-speed steel. Any wounds caused by it are very painful and take a long time to heal.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

From a cursory examination of some of the mechanical toys exhibited for sale in the shops and stores in great numbers at Christmas time, it would seem that the makers thereof have arrived at the acme of accomplishment in the manufacture of machines that will actually run—for a very brief period—and then, like the deacon's "one-horse shay," they go to pieces all in a day.

An amusing example of the perplexities that frequently beset the piecework shop was furnished at the last meeting of the National Railroad Master Blacksmith's Association. In the discussion on high-speed steel one of those who took part related how one of their machine men had suddenly greatly increased his output over that of the other men. For some time it was a mystery how he was able to turn out work so fast, and then it was discovered that he was more progressive than the firm and had secretly bought some high-speed steel for his own use, and was thus reaping the benefit of his progressiveness in the shape of good hard cash. Now let the managers of piecework shops arise and tell us how they would have handled a case of this kind prior to finding out what was the reason of this man's extraordinary production, and what they would have done afterward.

A circus train was pulling out of Spokane, Wash., a few weeks ago when suddenly the injector "broke" and persistently refused to take up water. After working with it a few minutes the engineer ordered an examination made of the tank; it was found nearly empty, although filled at the water crane but a short time before. No explanation of this mystifying condition was apparent until water in numerous streams was seen running from the elephant car next to the tender, and then the cause was found. "Jumbo" had amused himself by reaching his trunk through the open end of his car into the manhole of the tender and sucking up the water with which he had deluged the other animals in the car. They looked like "drowned rats," and needless to say had enjoyed their involuntary baths no more than the trainmen had the delay.

Not long ago it was freely predicted that much of the large machinery provided in our leading electrical and steam engineering works would become more or less useless on account of the much smaller sizes of units made possible by the steam turbine, but apparently the growth of the big machine tool industry will suffer little or no check from the advent of the steam turbine. The huge turbines now building for the 25-knot Cunarders have made necessary the building of a number of large special machines, one being a boring machine for the casings, constructed by Thomas Shanks & Co. for John Brown & Co., Clydebank. The total weight of this machine is about 95 tons and it has an over-all length of 76 feet. The base plate is 17 feet wide and 53 feet long, with wings bolted to each side where necessary to serve as supports for the overhanging parts of the turbine casings.

One of the interesting exhibits at the Louisiana Purchase Exposition was a steel boiler plate made by Worth Brothers, Coatesville, Pa., which is said to be the largest boiler plate ever rolled. It is 558 inches long, 142 inches wide, and 0.72 inch thick. The total weight is 16,120 pounds. The tensile strength of the material is 58,000 pounds per square inch; the elastic limit 37,000 pounds; and elongation 37 per cent. There is a most striking difference between this monster plate and the small iron plates available, say, one hundred years ago. It will be remembered in the article "Early Steam Engines.—3," which appeared in the August, 1904, issue of MACHINERY, it was stated that the firebox of the boiler of the Center Square pumping engines at Philadelphia, Pa., was made of wrought-iron plates 15 x 36 inches. These were the largest that could be obtained at that time.

In a paper on the modern steam fire engine read by Mr. F. F. Loomis before the ninth meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers, it was stated that the first steam fire engine dates back to 1840 and was built by Mr. P. R. Hodge, a mechanical engineer of New York City. Strange to say this machine was of the automobile type, being self-propelling. The rear wheels, which were the drivers also, served as balance wheels when the engine was in use at a fire, the machine then being jacked up so as to clear the ground. Although it worked very well for its small capacity, weighing only 3,000 pounds, it was opposed by general prejudice and by the volunteer fire departments of those days, and allowed to fall into disuse. Mr. A. B. Latta built the next steam fire engine for the city of Cincinnati in 1852, and its great success paved the way for its general adoption in all cities.

The ice man is an important personage during the hot term, but there are indications that his vocation may be less important to many in future years. The ideal condition for every household maintaining a refrigerator would be that in which a refrigerating system is operated by power, preferably electric. Then the refrigeration could be maintained as the weather demanded, and not as suited the convenience of the ice man. We understand that a small electric refrigerating plant for the household has been placed on the market which has a capacity equal to the melting or use of about 200 pounds of ice per day. It is said to be automatic, and so simple in the matter of care as to be operated by the ordinary kitchen help. It is driven with a one-half horse power electric motor, which operated about half of the twenty-four hours will manufacture nearly 20 pounds of ice, besides refrigerating two storage compartments to a temperature of 35 to 38 degrees F.

Professor Bach recently made some experiments to determine the effect of high temperature on the strength of steel. The tests were made on groups of four bars each. The first four were tested at ordinary temperature, and the other lots at 390, 570, 750, 930 and 1,020 degrees F. respectively. At ordinary temperature the tensile strength of one bar was 54,000 pounds per square inch and the elongation 26.3 per cent. The tests on the successive lots showed that the strength increased with the temperature up to 750 degrees F., at which the total increase was about 6,300 pounds per square inch, but above this temperature the strength decreased directly with the temperature, and was found to be only 26,000 pounds per square inch at 1,020 degrees F. As a result of these tests the professor thinks that boiler steel plate should also be tested at higher temperatures than normal, as there are surprising variations from the results of tests made at ordinary temperatures.

In the paper "The Development and Use of High Speed Steel," read by Mr. J. M. Gledhill before the Iron and Steel Institute, it was intimated that the famous Damascus steel of antiquity, to which marvelous cutting powers have been attributed, is really a form of high-speed steel, containing as it does those alloys which have been found necessary in the manufacture of our modern product. He states that Damascus steel contains certain percentages of tungsten, nickel, manganese, etc., and hence a latent high speed steel may be said to have existed centuries ago. All that was necessary to bring out its inherent powers was a very high temperature, such as was long thought to destroy its nature, in other words, "burn" it. It remained for Messrs. Taylor & White, of the Bethlehem Steel Co., to burn alloy steels and thus develop their high-speed quality which perhaps has worked and is working the greatest revolution in machine shop practice.

According to the statement made by the United States consul at Milan, Italy, that government has recently made an

interesting experiment with automobiles to demonstrate their emergency value in war time. Fifty owners of automobiles were invited to take part in the maneuvers and thirty responded. Thirteen routes were selected from Brescia leading to various points on the eastern, western, and northern frontiers. The thirty machines participating all left the town in the early morning, each bearing a sealed order containing the route laid out for that machine. The distance had to be covered within twenty-four hours, and means had been provided for verifying the routes, times of departure, etc. All the cars returned to Brescia before midnight of the same day, and only one of them had an accident. The longest distance covered was 335 miles. The result of the test is said to be highly gratifying to the military authorities, as it proves the great value of the automobile in war time for transporting officials, papers, maps, light apparatus, food, etc.

One of the most famous patents in the matter of litigation is that of James Knibbs, who some forty years ago invented a relief valve for fire engines. The invention was very simple, but is a very valuable adjunct to the steam engine, being practically indispensable in fire fighting. It essentially consists of a relief valve and pipe attached to the box to which the pumps deliver the water, and from whence the streams are distributed to the various lines of hose. The pipe to which the relief valve communicates leads back to the suction of the pump. When the fire engine is supplying water for fighting a fire, the demand for water is likely to be the full capacity of the engine, but one or more lines of hose may be suddenly shut off at any time without warning to the engineer. Without the relief valve the pressure would likely rise so high as to burst one of the remaining lines of hose, but with the Knibbs device the excess pressure merely raises the valve and allows the water to flow back to the suction where it is pumped over and over again. Thus not only the hose is protected but water is saved and the flooding of the streets prevented. Knibbs neglected to patent his invention until it had been used over two years. He then secured a patent for it and its use became general on fire engines. In 1877 suit was begun against New York City for infringement of the patent, and as time passed on the claims mounted up to over $26,000,000. The United States Circuit Court recently decided in favor of the city, holding that Knibbs had abandoned his invention, inasmuch as he did not secure a patent within two years of its inception.

RAISING THE MAINE.

Since the sinking of the *Maine* in Havana harbor, February 15, 1898, there have been many rumors that the wrecked vessel was to be raised by private contractors who expected to be recompensed for the work by the actual value of the vessel and its equipment, and the curiosity of the public who would be willing to pay a good admission price to view the relic. None of these proposed schemes have resulted in any actual work being done, so far as we know, but it now appears from the *Engineering News* that plans have been made, and work will soon be started by a salvage company. The United States government has relinquished all claim to the battleship, and it is now the property of the Cuban government, which desires to remove the obstruction from the harbor, where it is a serious menace to navigation. The salvage company proposes to build an immense wooden circular coffer-dam 354 feet inside diameter, with inner and outer concentric timber walls spaced 8 feet apart. Each wall will be composed of 3-inch pine planks, and the inner and outer walls will be tied together by radial and diagonal planks, and ¾-inch tie rods. The depth of the water where the Maine sank is about 35 feet down to a mud stratum, and the mud is about 20 feet deep before a hard stratum is reached, hence the coffer-dam may have to be built fully 55 feet high, provided it is found necessary to sink it completely through the mud stratum. It is proposed to build the dam complete and sink it around the vessel by loading it with about 2,000 tons of ballast. Water will also be admitted within the inner and outer walls. When the dam has been sunk to the mud stratum pumping will begin, which will facilitate the sinking of the dam through the mud. When the water has been pumped out, the work of temporarily repairing the vessel so that it can be floated will be done. The company is alive to its opportunities and will charge photographers a high price for taking photographs of the work and of the wrecked vessel as it is uncovered. They also propose to make up souvenirs of brass, bronze, and copper, which will be sold as mementos, and will be accompanied by certificates of Cuban and American officials as to their genuineness. After the vessel has been floated, it will be placed on the Havana floating drydock and there completely repaired. When repaired it is proposed to exhibit it in the principal seaports of the United States and charge visitors an entrance fee for the privilege of going over the vessel. After all these various sources of revenue have been exhausted the company will have on its hands a complete battleship which they will sell to some government. The Maine cost the United States something like $5,000,000 to build and equip, and the machinery alone cost $735,000. The proposed work is of great interest from both an engineering and a historical standpoint, as the coffer-dam proposition is perhaps the most ambitious of the kind ever projected, and, if successful, it will restore to the world a vessel round which much sentiment centers.

FANS VS. POSITIVE-PRESSURE BLOWERS.

An interesting and valuable paper to foundrymen was presented at the March 7th meeting of the Pittsburg Foundrymen's Association. It described tests which were made by a committee appointed by the association for the purpose of determining the relative efficiency of fans and positive-pressure blowers. The tests were conducted at the works of McIntosh, Hemphill & Co., on a 54-inch cupola, under the supervision and direction of Mr. W. H. McFadden. The first test was made with a Sturtevant No. 10 fan, driven by a 50-horsepower, 220-volt, shunt-wound motor. For the fan test the motor was run at a speed of 839 revolutions per minute, and the power required throughout the test was determined from voltmeter and ammeter readings. 60,700 pounds of metal was charged into the cupola, one-half being scrap and one-half pig. The test began at 2:02 P. M., and at 3:30 the first iron was run into the ladle, its temperature being 2185 degrees. The test was concluded at 5:50 P. M. During this period the average pressure of the blast was 13.6 inches, the average power required 35.8 electric horse power, and 57,680 pounds of iron were melted. The average amount of iron melted per hour was 15,312 pounds; 17,200 pounds per hour were melted during the first part of the heat, 15,000 pounds during the middle period, and 12,200 pounds at the last. The second test was made two days later with a 33-cubic foot Connersville blower. The same conditions existed as with the previous test with the exception that the piping to the cupola contained one more elbow. The same motor was used to drive the blower, and the cupola was charged with the same proportion of iron and scrap, but 63,000 pounds were charged instead of 60,700 as before. This test began at 2 P. M. and continued until 4:50. The average wind pressure was 20⅝ inches, and the average electric horse power was 40.6. The first iron was run into the ladle at 3:30 and indicated a temperature of 2165 degrees. The total amount of iron melted was 59,677 pounds and the time required was 2 hours 49 minutes as against 3 hours 46 minutes with the fan. During the first of the heat the iron was melted at the rate of 20,500 pounds per hour, during the middle at the rate of 22,300 pounds, and during the last at the rate of 17,700 pounds. A complete log of the tests shows that the average electric horse power for the fan was 35.8 and for the blower 40.6, as has already been stated. The highest horse power required for the fan was 43.2 against 48.3 for the blower. The fan required 134.8 horse power hours for 60,700 pounds, while the blower required 114.49 horse power hours for 63,000 pounds. Hence the fan required 4.41 horse power hours per ton of iron charged, and the blower, 3.63 horse power hours per ton, making a difference of 0.78 horse power hours in favor of the pressure blower; the difference in time for melting the two heats was 57 min., also in favor of the blower. This would allow the user of the blower to postpone putting on the blast

about one hour longer for a 30-ton heat than could be done with a fan. It has been found that the blower causes a much greater wear on the lining of the cupola than does the fan. Additional tests of a non-official character were also made with a No. 8 Sturtevant fan. The conclusions of the author are as follows:

1. The test has proved that, under favorable conditions, a 40-horse-power motor is sufficient to supply power for a blower or fan furnishing blast for a 54-inch cupola.

2. The rate of melting is not proportional to the amount of air supplied to the cupola. Too much air will tend to cool the cupola around the tuyeres and thus reduce the melting area.

3. In a 54-inch cupola when all heavy scrap and pig was charged, the 33-cubic foot positive pressure blower melted more economically and faster than did the No. 10 fan blower.

4. A No. 8 fan melted much more economically and faster when the cupola was kept open by a small amount of light scrap than did the No. 10 fan when all heavy scrap was used.

5. The high pressure produced by the positive-pressure blower has a much more severe cutting effect on the lining than had the lower pressure produced by the fan blower.

6. The original cost and the cost of installation of the positive-pressure blower would considerably exceed that of the fan blower.

7. The actual saving in horse power is not a large item. The saving due to the shorter time taken by the blower would depend upon the number of men employed and the price of work.

8. The difference in economy between the two types of blower depends largely upon the cupola practice. The above tests would indicate that where the tuyeres were kept clean and the cupola not packed too tight, there would not be any great difference in favor of either of the types of blowers. If the tuyeres are allowed to become partially closed, the positive type would prove the better.

EXPERIMENTS WITH HIGH-SPEED STEEL DRILLS.

Abstract of Paper presented by W. W. Bird and H. P. Fairfield before the December Meeting of the American Society of Mechanical Engineers.

The introduction of the high-speed twist drill into modern machine shop practice has brought with it many new problems and the tests recorded in this paper were designed to supply some definite data on the subject.

In order to measure the twist or moment and the thrust of the drill an apparatus was devised to go on the table of a milling machine, the drill being held in a chuck in the milling machine spindle. The apparatus is in effect a double dynamometer. It consists of a chuck with trunnions, mounted on roller bearings so that it is free to revolve about its axis; at the same time it is free to move in the direction of its axis, being mounted on a carriage which is on rolls resting on the frame of the machine. This frame was placed on the table of a milling machine so that the axis coincided with the center line of the drill, which was driven by the spindle of the milling machine. The thrust of the drill is transmitted through the trunnion of the chuck to a plunger which is fitted to a long cylinder filled with oil. At the end of this cylinder is a smaller one also carrying a plunger. This small plunger is attached to a ball-bearing piston in a regular indicator. The drum of the indicator moves proportionately to the feed so that the card taken is a record of the thrust during the drilling of a hole. The chuck is held from turning by a steel band which is attached by a yoke to a second indicator, and a card from this one shows the twisting moment at each stage of the operation. Both indicators were calibrated before and after the tests.

The correct moments were obtained by hanging known weights over the chuck and noting the rise and fall of the pencil point. The thrust cylinder was placed in an Emery testing machine and known loads applied, and a corresponding record taken on the cards. From these tests, curves were plotted so that readings from the cards could be readily reduced to pounds. It was decided to take up first the drilling of cast iron with high-speed steel. Blocks of soft gray iron were obtained and tested in the machine itself so as to get a number for each set of experiments as near the same degree of hardness as possible. A ⅝-inch Novo steel drill was taken as a good representative of the new steels.

The first experiments were on the effect of speed or number of revolutions per minute, all other conditions remaining the same. The revolutions were varied, from 140 to 600, but no material difference was shown by the cards in either thrust or twist. In other words, the power required to turn the drill varies directly with the number of revolutions, while the thrust does not increase with the speed, but depends upon the feed or the advance per revolution.

The next set of experiments was made to determine the relation between thrust and feed, the revolutions per minute remaining constant. From the first set of experiments it was shown that the limit of speed would depend upon the endurance of the drill, and with heavy feeds 420 revolutions was not far from this limit. Accordingly, the second set was run at this speed, which for a ⅝-inch drill is about 70 feet per minute for the cutting rate for the outer edges, and for .020-inch feed a rate of drilling of about 8 inches per minute. The range of feed was taken from .004 to .020 inch per revolution, the drill at the coarsest feed being somewhere near its limit. These feeds were all positive, a train of gears being substituted for the regular belt drive. The following table shows the results:

Feed—inches per revolution—

TABLE I.

.004	.006	.008	.010	.012	.014	.016	.018	.020
Thrust—total in pounds—								
240	280	330	360	410	460	525	620	725
Moment—total in inch-pounds—								
55	67	83	92	103	115	124	132	138

The figures in regard to moments indicate that less power is required to drill a given hole in a given time by increasing the feed per revolution rather than by increasing the revolutions. For example, to drill a hole in a 1-inch plate in 10 seconds could be done by running the drill 600 revolutions per minute and feeding .010 inch per revolution, but would require more power than by running at 300 revolutions with a feed of .020 inch. The question of proper angle of drill was next considered and a set of experiments made with a constant speed and feed, the half angle varying from 37 degrees to 70 degrees, 22 degrees less and 11 degrees more than the standard 59 degrees. The following table shows the results:

TABLE II.

Angle of drill, deg.	37	45	50	55	59	65	70
Thrust in pounds..	215	225	240	260	290	325	375

It was found that with the drill ground with a smaller angle than 59 degrees there was less thrust, but when the angle was as small as 37 degrees, however, the drill would not stand up on repeated work. At 45 degrees it seems to do the work as well as at 59 degrees and with much less thrust. This would suggest a change in the standard angle for the new steels. The moment for the various angles remained practically constant, so that the driving power does not change with the angles of the drill.

Another interesting point in drilling which can be shown with this machine is the effect of first removing the center of the hole by the use of a small drill. Ten holes were drilled in a bar of cast iron with small drills, ranging from No. 53 to ½ inch in diameter and then each one counterbored with a ⅝-inch drill at 420 revolutions per minute and a feed of .008 inch per revolution.

Table 3 gives the thrust in each case and shows that a hole 1-10 inch in diameter takes off about one-half the thrust for a ⅝-inch drill.

TABLE III.

Size of first hole—										
.000	.0595	.0760	.0935	.120	.157	.189	.221	.250	.375	.50
Thrust for counterbore—										
340	190	180	170	155	145	130	120	90	70	30

CONDENSERS FOR STEAM TURBINES.

Abstract of Paper by George I. Rockwood, read before the December, 1904, Meeting of the American Society of Mechanical Engineers.

Mr. Rockwood has recently installed a 400-kilowatt Westinghouse-Parsons turbine at the Atlantic mills, Providence, R. I., and in this paper gives some of the results of his experience with the installation, especially with reference to the condenser outfit. The condenser used is a 16-inch Bulkley injector condenser, and the falling of the injection water through the throat of the condenser is what constitutes the air pump, and it is found to be the only air pump needed, since a vacuum of 28½ inches of mercury can be maintained, regardless of whether steam is passing through the turbine or not. The action of the condenser is such as to warrant the belief that a 14-inch condenser would answer every requirement for a 400-kilowatt turbine.

The injection water comes 500 feet from the river to the power house under a slight head and is elevated into a vertical tank 30 inches square by 15 feet deep. The level of the water in this tank is maintained 6 inches below the water inlet nozzle of the condenser, and the injection pipe takes the water from the tank at a point near the bottom. Apparently the depth of the tank acts efficiently as an air separator, in view of the excellent vacuum maintained, and no air in the form of bubbles can be detected passing over into the condenser with the water.

The cost of a condenser equipment of this type, fully installed, with centrifugal circulating water pump, tank, piping and valves, ranges from $2.00 to $2.50 per kilowatt, and the room occupied is practically none at all.

In contrast to this is the experience of the unusually large condenser and auxiliaries usually found in turbine plants which, by comparison with the diminutive turbine, appear unduly prominent. Aside from the type installed by Mr. Rockwood there are three other accepted designs for turbine condenser plants:

1. The combination of a surface condenser, a centrifugal hot well pump, an air cooler, a single-cylinder dry vacuum pump, a centrifugal circulating pump with their connecting drip piping and valves.

2. The same arrangement, but with the hot well pump, the air cooler and dry vacuum pump omitted, substituting therefor the wet vacuum pump—preferably of the Edwards type. The cost of these two equipments is about $7.00 to $10.00 per kilowatt.

3. An equipment like the first, except that an elevated jet condenser with a barometric tube and hot well takes the place of the surface condenser and hot well pump. This takes up less floor space and costs but $5.00 to $6.00 per kilowatt. The dry vacuum pump used with barometric condensers must have a two-cylinder air pump, and the exhaust from the turbine cannot be used again in the boilers.

The author contends that the injector condenser would seem to bar out all other condenser systems in situations where the water is pure. For example, if the city water is pure and costs about seven cents per 1,000 gallons, water enough for a 400-kilowatt machine at 100 per cent load factor would cost per factory year of 310 days, 10 hours a day, at 1,000 gallons per hour, about $217. With interest at 5 per cent and fixed charges at 8 per cent this sum warrants the capital expenditure of not to exceed $1,670. It is thus clear that it does not pay to buy the surface condenser system simply to save the cost of paying city rates for boiler feed-water. Where the feed water contains salt, sulphate of lime, acid, grease or other hurtful pollution, however, then it pays to use one of the surface condenser systems.

Much talk has been made about the freedom of the condensed exhaust steam in turbines from cylinder oil, and the advantage which this purity gives to it as compared with the oily exhaust from reciprocating engines, where the condensed steam is returned to the boilers.

It should not be forgotten that great purity of feed water is not in itself a desirable thing, being only better than very impure water; for it pits the tubes and water legs of steel boilers, unless some lime is added. Where the waste injection water from a jet condenser is used for washing in a dye house, this freedom from oil is a great advantage. Such is the aversion of dyers to using exhaust steam to heat water on account of the supposed presence of cylinder oil—no matter how careful one may be to provide, and operate successfully, oil eliminators—that this freedom of the turbine from the use of cylinder oil is sufficient cause to determine the purchase of turbines in place of engines for power in such places.

The method of sealing the spindle of the Parsons turbine against air leak where it passes out to its journals from the low-pressure chambers, namely, by pumping water with centrifugal pumps formed in small recesses in the shaft cover, so as to keep a water pressure in these recesses in excess of that of the atmosphere, is a perfect success.

In starting the turbine at the Atlantic mills, injection water is first turned on, then steam is admitted to the turbine without admitting water to the air seals where the shaft passes through the turbine casing. After the load begins to come on, the drip pipe from the exhaust chamber to the atmosphere, which has been open all night and up to this point, is now closed, the water turned on to the air seals, and the vacuum immediately draws down to 28 inches. It is not found absolutely necessary to start in this way, as the turbine can be run hours before the water accumulates in quantity. The object is simply to drain the turbine up to the moment when the load begins to come on.

It is necessary to exclude any accumulation of water in the exhaust pipe for fear that it will sway back and forth until it flushes up on to the large low-pressure blades of the turbine. Running as they do at a very high velocity, sudden contact with water from the exhaust pipe will strip the last row off clean if such contact is permitted. Any further damage, however, to the other rotating blades seems to be prevented by the presence of the fixed row, which, by dividing up the water into small streams, seems to protect the moving rows from contact with solid water and therefore from injury. It is not, however, necessary to provide a drip pipe or drip pump, for removing the water of condensation or the leakage into the exhaust chamber from these air seals.

DIAMOND TOOLS.

Abstract of Paper by G. C. Henning, presented at the Meeting of the A. S. M. E., December, 1904.

Steel is, of course, the one material in almost universal use for cutting and working stone, metal, wood and other materials, because of its great strength and the degree to which it can be hardened. There are some materials, however, which, because of their hardness, structure or non-conductivity of heat, cannot be worked economically by means of steel tools. The latter become worn rapidly, losing their shape and dimensions to such degree and extent that the work produced becomes inaccurate, causing constant interruption of operation, loss of time, and the use of new tools or frequent regrinding or shaping of the old ones. This causes great expense and delay in production. The great friction produced by cutting materials in some cases draws the temper of steel tools, making them useless. Hard rubber, paper and hardened steel cannot be readily worked by use of steel tools, as is also the case with hard stone. In these cases a much harder material is required, and for this reason diamond is used. The diamond used is of two kinds, totally different in appearance and quality. 1. The black diamond has a very dark purple brown color, and is an amorphous, granular stone with rarely any crystallization visible or traceable. It is called carbon or black diamond. It is the hardest material known and has great strength. 2. Bort, is entirely crystalline, and is generally transparent and of all colors of the rainbow, as well as clear and transparent as glass. The latter is considered of greater hardness than all other bort except some which is almost black. Bort is extremely brittle and is readily fractured or "cleaved" in the three directions of its cleavage planes parallel to the sides of the octahedral crystal, in which shape it is most commonly found. The dodecahedral crystals are also readily cleaved in a similar manner.

In spite of the very great hardness of all kinds of diamonds, they are readily sawn, drilled, cut and polished; carbon (black

diamond) cannot, however, be polished, as is the case with bort.

Diamond cuts diamond, while steel saws and drills, and cast iron discs charged with diamond dust are used for the other operations. All kinds of grinding wheels, being made of extremely hard materials, are most readily kept free from filling or glazing and in perfect shape by diamond tools. In certain classes of work, where great accuracy and precision are primary requirements, or extremely fine lines are essential, the diamond is the only material that answers the purpose. Thus lithographers, engravers and scale-makers use them for fine work. Another very important field of production in which diamond is all but imperative to obtain satisfactory results at reasonable cost is that of wire drawing. Formerly all small wire was drawn through holes in hardened steel plates, but these wear so rapidly that the wire soon loses its caliber and becomes unround. As it is all-important, especially in electric work, that the wire be of absolutely uniform size, so as to maintain constant resistance and permit symmetrical distribution of weight about spindles and shafts, it became necessary to use a material harder than steel, and hence diamond was again resorted to. This made it possible to avoid delays in replacing worn dies, and because of the great permanence of accuracy of the calibers of the holes in the diamonds, the cost of producing fine wire of copper, brass, steel, iron, nickel, and of other metals was materially reduced.

It is, of course, well known that stone is drilled and sawed by the use of diamonds, these having been used in core drills, which, in an extreme case, have cut solid cores of about 21 inches diameter. In diamond drills, stone saws and grinding wheel dressers, the rough diamond is used in appropriate holders, set either by staking, brazing, soldering, or by casting molten steel around the diamonds. A peculiar property of the diamond is that it can be plated like any metal; this property is made use of in the galvanoplastic setting. The galvanoplastic setting consists in first plating the diamonds and then casting other molten metal around them, which alloys with the deposited metal. Thus an absolutely firm and rigid setting is produced.

Very high temperature does not affect the diamonds either in their hardness or, when sound, in their solidity, and does not produce checks or other flaws. A temperature higher than that sufficient to melt steel will, however, burn the diamond, and that of the electric arc will do so readily. The diamonds in tools used for doing accurate work are, however, all "shaped" by cutting and polishing, so as to imitate the customary shapes of steel tools.

Glass and china are also drilled by shaped diamonds, in which case a triangular splint is generally provided with a flat triangular pyramidal point, which, when using turpentine as a lubricant, penetrates glass and china more readily than any other tool, and lasts for from one to two years, unless broken by carelessness or accident. There are various styles of tools. In the round-nose tool, the diameter or curve of cutting edge and its clearance from a right angle can be produced at will. In the sharp-nose tool also the angles can be varied at will. The square-nose tool is used mainly for producing very high finish of hard rubber, and a tool commonly used for turning paper calender rolls, which must be very accurate and smooth, consists of a piece of black diamond shaped as a round-nosed tool, and simply clamped in proper position between two pieces of steel. The last three tools are most commonly used for turning hard rubber, because the diamond lasts a very long time without wear and produces absolutely smooth and accurate work, while steel tools wear off in a few minutes at most and get very hot. One other reason why it is economically advantageous to use diamond tools for turning hard rubber is that very high speeds can be used, 450 to 500 feet per minute being common.

It may here be added that diamond tools are most suitable for working carbon used for electrical purposes.

A diamond die used for drawing wire consists of a bronze block in which is set a diamond perforated by a tapering, polished hole through which the wire is drawn. The holes in these diamonds are rarely made larger than .064 inch diameter, because steel draw plates or dies are considered sufficiently accurate and economical for larger sizes, and because of the great cost of diamond dies. The smallest dies which have come to the notice of the writer had holes of .001 inch diameter, although clients have called for calibers as small as .00045, .00055 and .00065. It is common practice to make the holes in diamond dies accurate to .0001 inch, which to many engineers may seem almost impossible, and is therefore here mentioned. In drawing copper wire, it is customary to draw a .064 wire in one pass from a rough wire of .072 diameter. Smaller sizes are then produced by the following consecutive reductions: to .053, .045, .040, .036, .032, .028, .025, .022, .020, .019, then by 1-1000 down to .0075 and by half-thousandths down to .001.

It may be mentioned that diamonds wear increasingly when drawing the following metals in the order stated, viz.: gold, silver, copper, brass, bronze, platinum, soft steel, nickel, iron and crucible steel (piano wire).

In order to show why such expensive material as diamond can be used economically it may be stated that diamond dies wear up to eight years under constant use. One die of .004 caliber has, according to the record, drawn over 550,000 pounds of soft copper wire. Diamond drills for drilling glass wear from one and one-half to two years before requiring recutting.

As is well known, diamonds are also used for spindle bearings in watches, and most recently have been introduced as cupped bearings for the pivots of electric meters, because they produce the minimum of friction, and do not wear out in many years. Another purpose for which diamonds are used is that of drilling teeth, especially artificial teeth. In these drills minute chips of diamonds soldered into steel shanks are used. These diamonds are not prepared in any manner, as their points and edges when properly selected are sufficiently hard and sharp to penetrate bone and porcelain. The shapes of chips most generally used are flat, triangular points and three-sided pyramids. The most perfect drills for this purpose have diamonds of triangular sections with a pyramidal polished point.

THE BURSTING OF FOUR-FOOT FLYWHEELS.

Abstract of Paper by Prof. C. H. Benjamin read at the December, 1904, Meeting of the A. S. M. E.

Prof. Benjamin has continued his destructive work of bursting flywheels, for the benefit of the engineering public, by running some tests of this character upon flywheels four feet in diameter. To insure safety to the students and to the building of the Case School of Applied Science, these tests were conducted outdoors, in consequence of which they nearly proved disastrous to the neighbors. The flywheels were run in a casing of steel castings, located in a pit lined with brick. The flanges of the lower half rested on brick piers and were bolted in place. The entire upper half of the casing could be hoisted up, giving access to the interior for hoisting or removing the wheels. Two wheels were broken successfully, but the third one burst through its bounds and carried the casing with it many feet in the air. Fortunately, every precaution for safety had been taken, all the observers being located far away from the plane of rotation of the wheel. These interesting experiments are to be continued, but hereafter the wheels are to be mounted on a vertical shaft and are to run in a pit in the ground, so that however great the violence with which the wheels go to pieces no possible harm can be done.

In carrying out these experiments the shaft supporting the wheel to be tested turns in bearings bolted to angle irons on the lower halves of the side plates, and was connected to the driving mechanism just inside the building by a flexible sleeve coupling. After the wheel was in place, the casing was lined with wooden blocks to absorb the momentum of the flying fragments. Instead of using a steam turbine as in former experiments, the flywheel shaft was speeded up by means of a Reeves variable speed countershaft, interposed between line-shaft and the driving-shaft.

The first wheel to be experimented on was a well-proportioned cast-iron pulley, such as is used on shafting for transmitting power. This pulley was 48 inches in diameter, had six arms and weighed 194 pounds. The rim was whole and was 8½ inches wide and about ⅝ inch thick, finished on

the outside. The arms were elliptical in section, 3⅛ inches by 1 1-16 inches at the hub, and 2 inches by ¾ inch at the rim. On the whole the wheel was well-designed and showed no signs of shrinkage strains. It had, however, been balanced in the customary manner by riveting a cast-iron washer inside the rim at the lighter side, and this proved its undoing. The combination of a thin place in the rim, a rivet hole and a heavy mass of cast-iron, is enough to wreck any wheel.

As has been shown by previous experiments on whole rim wheels of cast-iron, a bursting speed of 400 feet per second may be reasonably expected. The circumference of a four-foot wheel being about 12½ feet, such a wheel should burst at about 32 revolutions per second, or 1,920 revolutions per minute. The pulley in question burst at 1,100 revolutions per minute, as recorded by a tachometer connected to the driving-shaft. The balance weight weighed 3½ pounds, and its center was approximately 23 inches from the axis of rotation. At 1,100 revolutions per minute the centrifugal force of the balance weight alone would be 2,760 pounds. Add this radial pressure at a weak point between the arms to that due to the weight of the rim itself, and the low bursting speed is easily accounted for.

The linear speed of the rim at rupture was 230 feet per second. As 100 feet per second is considered the limit for belt speed, this pulley would have a working factor of safety of $(2.3)^2$ or 5.3. But suppose the rim had been a little thinner and consequently a bigger weight had been put on with a larger rivet?

Wheel No. 2 was a cast-iron pulley of the same general style and dimensions as No. 1, but with a split hub and rim. The balance-weight was present here as in the former case, but was obliged to yield the palm to its rival, the flanged joint. The wheel had been cast in one piece, as is usual in such cases, with cavities cored at the joints of rim and hub.

After finishing it had been broken apart by wedges, making a fracture joint. The flanges, being located midway between the arms and bolted at some little distance inside the rim, were in the worst possible position to withstand the bending action due to centrifugal force, and their own weight only aggravated the difficulty. The flanges weighed with their bolts 7½ pounds. This wheel burst at less than 700 revolutions per minute, the tachometer not recording below this speed. The writer believes the speed to have been about 600 revolutions per minute. At this speed the centrifugal force of the flanges on one side would have been 1,680 pounds. At 600 revolutions per minute the linear speed of rim would be only 125 feet per second. At the very common belt speed of 4,500 feet per minute the factor of safety would have but 2.8, which is altogether too low, considering the nature of the material and the shocks to which a pulley may be exposed.

There is one instance on record of the wrecking of an engine by the breaking of a generator pulley, which had a heavy balance weight inside the rim.

It was reserved for wheel No. 3 to develop the most dramatic series of incidents of any yet experimented upon, big or little. This wheel measured 49 inches in external diameter and weighed about 900 pounds. The rim was 6¾ inches wide and 1⅛ inches thick, and was built of ten segments, the material being cast-steel. Each joint was secured by three prisoners of an I-section on the outside face, by link prisoners on each edge, and by a dove-tailed bronze clamp on the inside, fitting over lugs on the rim. The arms were of phosphor bronze, twenty in number, ten on each side and were a cross in section. These arms came midway between the rim joints and were bolted to plane faces on the polygonal hub. The rim was further reinforced by a system of diagonal bracing, each section of the rim being supported at five points on each side, in such a way as to relieve it almost entirely from bending. The braces, like the arms, were of phosphor bronze, and all bolts and connecting links of steel.

This wheel was designed by a Baltimore firm as a model of a proposed 30-foot flywheel.

On account of the excessive air resistance it was found necessary to enclose the wheel at the sides between sheet-metal disks, before any great speed could be attained. Even then repeated trials failed to reach a speed of more than 800 or 900 revolutions per minute on account of the great inertia of the wheel, and the consequent slipping of belts. But putting on more and wider belts, by a liberal use of "Cling-Surface" and with the aid of a 7½ horse power electric motor belted on in parallel, it was found possible to get a speed of 1,650 revolutions per minute, and after the wheel had been run at this speed it was stopped and examined.

The inspection showed fracture of several of the I-shaped prisoners on the outer surface of the joints and a slight opening of the joints themselves, to the extent of perhaps one or two hundredths of an inch. On June 2, 1903, the casing was closed for the last time, and the combination of driving mechanisms set to work. The observers were all well protected by the thick piers of the building, while other spectators were kept at a safe distance and well away from the plane of rotation. Two of the observers watched the pointer of the tachometer through opera glasses, another kept the time, while a fourth manipulated the driving levers.

As the hand of the speed counter reached and slowly passed the 1,600 mark, the feeling of suspense on the part of those watching reached the acute stage. The pointer crept slowly on and as it quivered on the mark of 1,775, there was a sudden crash, a sound of rending and tearing, and the writer saw the countershaft inside writhing on the floor like a wounded snake. On stepping outside he was saluted by a shower of falling splinters and fine debris, and was surprised—putting it mildly—to note the disappearance of the greater part of casing and wheel.

The steel rim of the casing was broken off short, six inches below one of the flanges, and the entire upper half weighing half a ton was projected about 75 feet into the air and landed some hundred feet away on the campus. On its way up it carried away part of the cornice of the building, and this collision was probably what caused it to deviate so much from a vertical path. The hub and main spokes of the wheel remained nearly in situ, but parts of the rim were found two hundred feet away, while one large fragment landed on the roof of the building.

This sudden failure of the rim casing was unexpected, as it was thought the flange bolts were the parts to give way first. The tensile strength of the rim at the point of fracture was about 1,200,000 pounds, or about four times the strength of the wheel rim at a solid section. Examination of the break in the casing showed a clean, bright fracture, with almost no imperfections.

The failure of the wheel itself was due to a gradual opening of the joints, occasioned by the fracture of the outside prisoners, and to flaws in the bronze castings of the arms near their junction with the rim. On putting the pieces of the wheel together in their original order it was easy to locate the joint which first gave way, on account of the symmetry of the breaks either side of a diameter through this point. It is but fair to the builders of the wheel to say that the fractures showed uniformity of strength and of workmanship, since there was hardly a member or a joint which did not fail in one part or another of the wheel.

One thousand seven hundred and seventy-five revolutions per minute means a linear speed of rim 22,300 feet per minute, or 372 feet per second. This is not as great as the probable speed of a solid cast-iron rim of good design, but it is greater than the speed of any sectional or jointed rim which has been tested. The tensile stress due to the centrifugal force at this speed is 13,800 pounds per square inch. This shows that the joints were much weaker than the solid rim. On the whole, the test of this particular wheel was disappointing, since its strength was not sufficient to repay one for the expense of the design.

It is interesting to compare the kinetic energy of the rim of the wheel at the recorded speed with the work of destruction. Assuming the rim with its lugs, flanges, etc., to weigh 300 pounds, which is a reasonable estimate, the kinetic energy at a speed of 372 feet per second would be 645,000 foot pounds. Further assuming that none of the energy was dissipated in heat, and that the combined mass of wheel and casing projected into the air weighed 1,500 pounds, we find the height of projection to be 430 feet. It is good cause for congratulation that four-fifths of the energy *was* dissipated.

STAYBOLTS, BRACES AND FLAT SURFACES.

December, 1904, Meeting A. S. M. E.

In a paper upon staybolts, braces, and flat surfaces, Mr. R. S. Hale compares the various rules for working stresses in staybolts, pointing out that in short bolts a bending action occurs which is more destructive than in the longer bolts. He also compares various rules for the strength of flat surfaces, and gives a table containing figures upon cases where bulges in boiler plate have occurred between staybolts. His general conclusions are as follows:

Stress on Stays.

Comparison of the various rules for working stress on stays and braces shows a general neglect of the difference between long and short stays. For the long steel stays, subtracting ⅛ inch from the diameter, and then allowing 12,000 pounds per square inch on net section, remaining gives results which apparently will be better than any of the present rules. For iron stays probably 10,000 should be used. For short stays, which are chiefly iron, where bending action comes in, empiric rules reducing stress as length of stay decreases may be used. Our knowledge of the bending stress is not sufficient to warrant the use of a more theoretic formula.

Pitch of Stays and Thickness of Plates.

Comparison of the working pressures for pitch of stays and thickness of flat plates shows that the complicated formulas of some of the rules do not give as good results as the simpler formula $P = C\frac{t^2}{p^2}$, C being taken as 100 to 115 for riveted stays, 140 for stays nutted or crowfoot stays riveted on, and a higher value up to 200 or 250 for the use of washers or channels or angle bars riveted on; P = steam pressure; p = pitch of staybolts in inches; and t = thickness of plate.

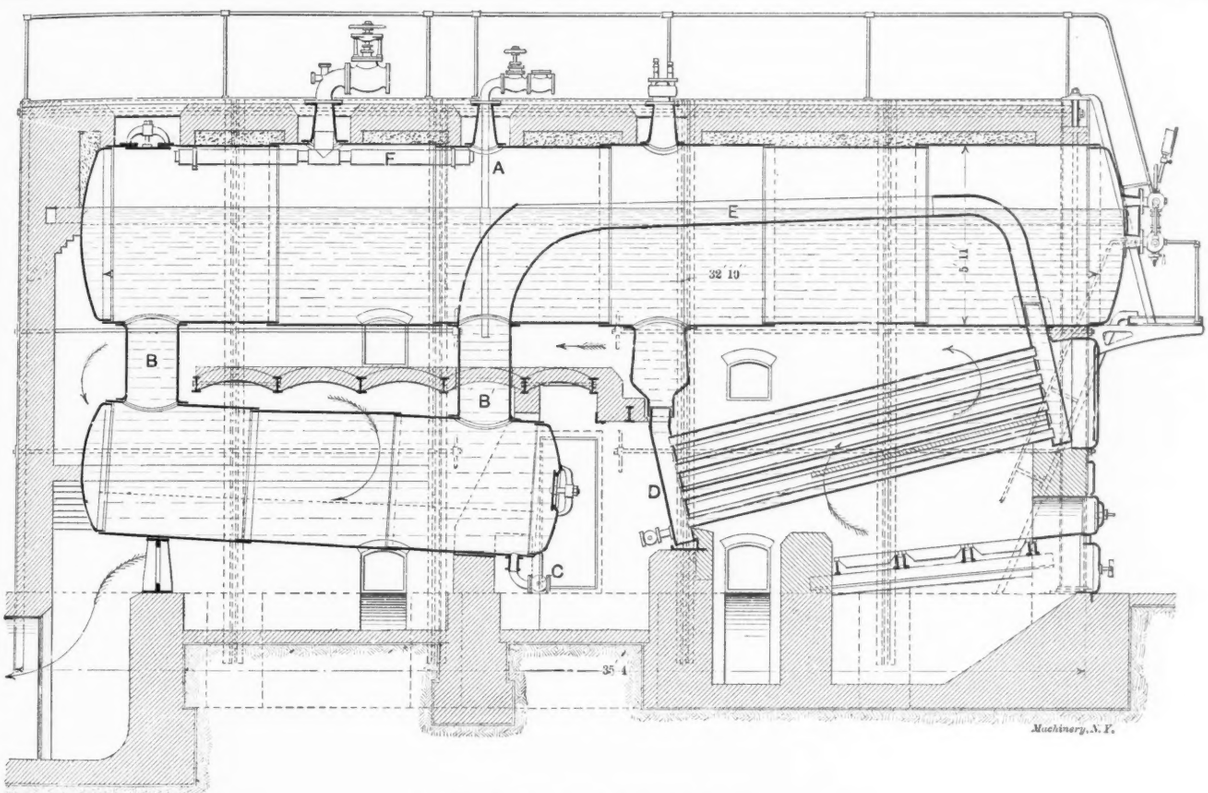
If the pitches differ by less than 20 per cent use the surface instead of p^2. If the pitches differ by more than 20 per cent it is a special case. Special cases and unusual construction must always receive special consideration.

The above constants give results indicating the probable safe pressure for a year or so, until the next examination. In designing a boiler for a long life the constants should be reduced by some 20 per cent or so, just as a factor of safety of 4 can sometimes be used temporarily for the shell of a new boiler, while 5 should be used in designing a boiler to be run for a number of years without reduction of pressure.

LARGE WATER-SPACE WATER-TUBE BOILER.

Der Praktische Maschinen Konstructeur, July 7, 1904, p. 106.

This boiler, which is exploited by the Rhenish Steam Boiler and Machine Works, has a claim of extra high efficiency of evaporation given it by its builders. The accompanying illustration shows that it is a compound of water-tube and cylindrical types with a special circulating apparatus. The water-tube section is at the front and closely resembles the Babcock & Wilcox type. At the rear of the rather long shell there is a mud drum placed beneath and in the passage of the gases as they come from the furnace. This mud drum is connected to the upper shell at two places and at the forward end it leads into a trough extending along the upper surface of the water to which the front header of the water-tube section also leads. This is intended to facilitate circulation. The course of the gases or combustion is up through the water-tubes,



Large Water Space Water-tube Boiler.

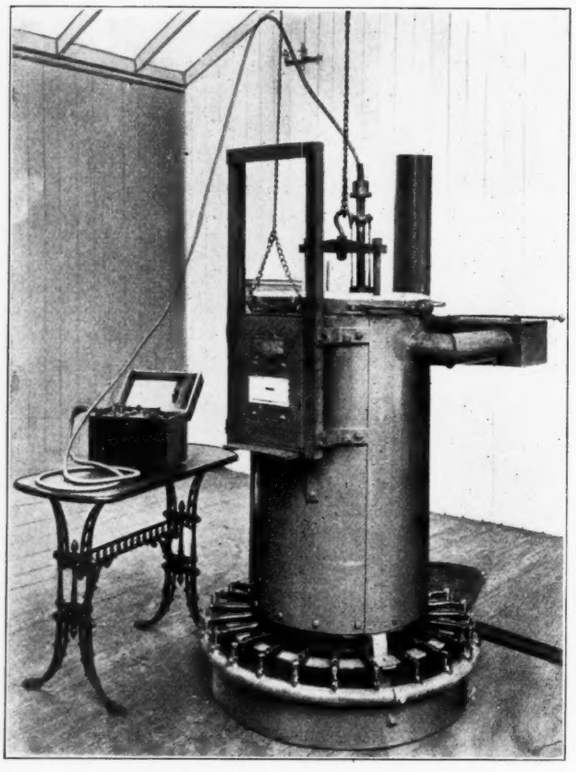
thence back beneath the water drum to the rear, where they turn forward to pass over the top of the mud drum to finally turn back beneath the latter and escape at the flue.

The circulation of the water is as follows: The feed is introduced through the top of the upper shell by means of the pipe *A*, which leads down to near the bottom of the same and over the forward connection of the mud drum. The water, on leaving this feed pipe, sinks down through the connection into the mud drum, where the blow-off cock *C* is located, and there it flows back to the rear end of the drum. Having become somewhat heated by the spent gases in the flue it rises through the connection *B* into the upper drum, where it is still further heated. In this condition it flows down through the connection into the back header of the water-tube section *D*, and streams from there out through the nest of tubes. Here it is partially evaporated and the mixture of steam and water issues from the front header through a connection, as shown, into the trough *E*, where they are separated. The water again drops down through the connection *B'* into the mud drum while the steam is stored above the water level. When the throttle is opened and the steam is drawn off, the trough *F* serves as a sort of steam separator. G. L. F.

A NEW HARDENING FURNACE.

A hardening furnace with a number of features of interest has been in operation at the New York offices of Geo. Nash & Co., dealers in iron and steel. It is a furnace made under the Brayshaw patents, the United States rights for which have been secured by this company, who are now in a position to place the furnace on the American market.

The contention made by the inventor is that the treatment of tool steel cannot be accurately regulated in an open furnace. In order to know what is being done it is necessary to immerse the steel in a liquid the temperature of which can be accurately determined. Mr. Brayshaw has experimented extensively with lead, but he considers a salt bath to be superior, and has patented a composition for such a bath. The operation of the furnace is based upon the well-known laws of the heating and cooling of steel, which are in no way a secret, but on the contrary well understood by metallurgists. If, for example, a piece of tool steel is gradually heated, the



Hardening Furnace and Pyrometer.

heat being supplied at a uniform rate, a point will be reached called the absorption point, at say 725 degrees C, or thereabouts, where the rise of temperature will be more gradual for a few minutes. After that point is passed the rise will then continue at about the same rate as before. In cooling, the temperature will drop regularly until the point of recalescence is reached, when the temperature for a few minutes, will not only cease to drop but will actually rise a slight amount. After passing this point, however, the drop in temperature will gradually resume its former rate. A peculiar fact is that this point of recalescence is lower by several degrees than the absorption point. In the specific case mentioned above it is about 700 degrees C, instead of 725. Mr. Brayshaw finds that it is impossible to harden steel at any point below the absorption point. For good hardening the temperature must be raised so that the absorption of heat is complete; but when this has been done the temperature may be lowered very considerably, so long as recalescence does not begin. In the case mentioned above, if the steam is first heated to above 725 degrees C, and then is allowed to cool down to nearly, but not quite, 700 degrees, it will still harden perfectly. He also finds that by adopting this method of heating carefully to a point above the absorption point, and then lowering the temperature, it is possible to harden steel at a very low point.

The object in designing the furnace was to take advantage of the above principle. A crucible is hung inside of the furnace for holding the liquid bath. The gas flames, coming from the Bunsen burners beneath pass up and around the crucible and heat it, and also the bath and the inner lining of the furnace, to a temperature determined accurately by a pyrometer, which is always in the bath. The pyrometer is read by means of a Whipple temperature indicator which operates on the principle of Wheatstone's bridge. The perforated metal tray can be raised and lowered inside the furnace, and pieces of the work placed inside the tray can thus be dipped into the bath or raised out of it without subjecting them to any change in temperature since the walls of the furnace are substantially at the temperature of the bath. Obviously, since it has been desirable to work between such narrow limits of temperature the heat of the furnace must be regulated carefully and this is done by watching the recording instrument and by adjustment of the main supply pipes for the Bunsen burners. In case of complicated cutters and other tools they can be heated up gradually in another furnace, if desired, before dipping in the bath, so the thin parts of such cutters will not be suddenly heated up to a high point before the heavy parts are heated. When placed in the bath the temperature is allowed to rise to what is known to be the correct point, assuming that any particular brand of tool steel is fairly uniform in character, and then the temperature is allowed to drop until the point is reached where the work is to be removed and plunged in the cooling bath. It is claimed that most complicated work can be hardened with little or no trouble by this means, and that results are very uniform.

* * *

THREAD DRAWN FROM MELTED QUARTZ.

The investigations of physicists generally require apparatus of the greatest possible refinement, and oftentimes it must be developed to a degree of sensitiveness hitherto unknown. Some years ago it was found imperative to discover a fiber for the suspension of certain parts of a bolometric apparatus used in the determination of the amount of heat received from the stars, that should possess properties found in no material then available. The fiber or thread required was to be used in supporting part of the apparatus subjected to very minute torsional force. Fibers of silk or steel or any known substance did not fill the requirements, inasmuch as they are unstable and do not possess the absolute perfect springy qualities necessary to return the needle to zero every time it is displaced. Moreover, it was necessary to find a fiber of the utmost tenuity which possessed the required qualities. Professor Boys experimented and discovered that melted quartz could be drawn into fibers of extreme tenuity, having an almost perfect torsional elasticity, if the operation could be done quickly. This requirement was satisfied by spinning the molten quartz from the pot by attaching it to an arrow which was propelled from a pine bow. Thus apparently one of the most unpromising substances for the support of delicate deflecting apparatus proved to be an almost ideal material. Lately it has been discovered that soapstone when highly heated can also be drawn into fine fibers possessing all the qualities of elasticity and resistance to chemical action characterizing the quartz fibers.

* * *

WALTER KIMBALL, OF RICHMOND, VA.

Last month an individual writing under the name of Walter Kimball, from Richmond, Va., with a letter-heading giving his business in machinery and tools, inserted an advertisement in this paper offering a number of standard machines at absurdly low prices, which caused considerable inquiry among the trade; several orders having been sent, and in one case a remittance made to cover the purchase. None of these orders was filled, and careful search in the city of Richmond failed to discover any person of that name in the machinery trade in that city. Further investigation shows that on November 26, last, he rented a room in a private residence at 315 E. Main Street, Richmond, where he roomed until the 14th of December, when he left without notice to the lady of the house, or giving any information concerning his whereabouts.

JIG AND MILLING FIXTURES WITH OPERATION SHEET.

B. P. FORTIN.

The accompanying drawings show jig and milling fixtures, and the operation sheet, Figs. 1 and 2, is also included as being of interest in connection therewith.

In my article of August, 1904, I described some of the obstacles to be met with in jig designing. Now some of these take-up," and this name was printed on the outside of a double sheet of paper, 9 inches by 6 inches, Fig. 1. The name can be written or printed, but the best plan is to have the sheets typewritten on bond paper, and the prints taken from them. The sheets can then be placed in some commercial cover; one that is arranged so the sheets can easily be changed whenever a change is made is the best. Each cut or hole has a name. On the inside of the sheet, on the left-hand side, Fig. 2, are the

LIST OF OPERATIONS AND TOOLS.

No. P. 14 Machine.

NAME OF PART.

GEAR RACK TAKE-UP.

	Operation		Tools.	Sheet No.
1	Clean Casting			
2	Drill shaft holes	2	Jig on Slate four-spindle drill	P 14-T-1
			1-4 Starter Drill	Stock
			7-32 drill	"
3	Square hubs	3	Special end mill	P 14-T-2
4	Finish ream shaft holes	4	1-4 Rose reamer	Stock
5	Mills for rack slide	5	Milling fixture on B & S No. 0 milling machine	P 14-T-3
	Roughing cuts for rack seat and finishing face		Gage cutters. Set fixture on base marked A	P 14-T-4
	Finish cut on rack seat		Special bevel cutter Set fixture on base marked B	P 14-T-5

Fig. 1. Outside or Title Page of Operation Sheet.

Fig. 2. Operation Sheet.

same difficulties are encountered in milling fixture construction—in fact, all of them except the need for lightness of fixture. First, as with drill jigs, they must be so designed as to be easily cleaned of chips, and to prevent possibility of work being put in in the wrong way. Another very important thing is the springing of work. Rough castings give the greatest trouble, and it often requires considerable thinking to design a fixture to clamp a delicate casting without springing it. Milling fixtures should have ample stock in the right place, to insure stiffness and a smooth cut. The cutter used should be as small as possible and close to the spindle, unless supported by the overhanging arm.

The operations for the job were gotten out in this manner: The name of casting to be operated on is called "gear rack

names of different cuts and holes, and on the right-hand side, opposite each operation, are the names of the jigs or fixtures and the tools used; also the kind of machine that they should be used on. The extreme right gives the sheet number of drawing and stock tools.

The drawing room and the manufacturing department each have a set of these sheets. Whenever a new job is started, by consulting the operation sheet, it is easily found whether the particular machine wanted for the job is in use. After finding this out, we next look at the operation to see what tools are wanted, and in making our wants known to the toolroom keeper, all the tools pertaining to this job are handed out. Each jig or fixture, with its tools, is kept in separate bins and is easily found.

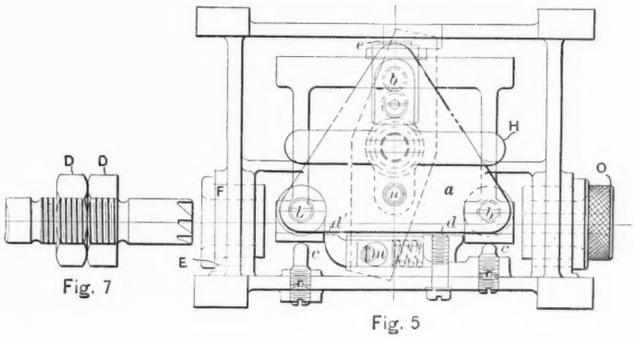


Fig. 7

Fig. 5

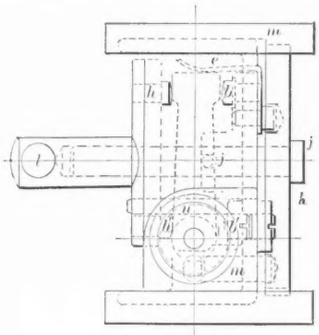


Fig. 6

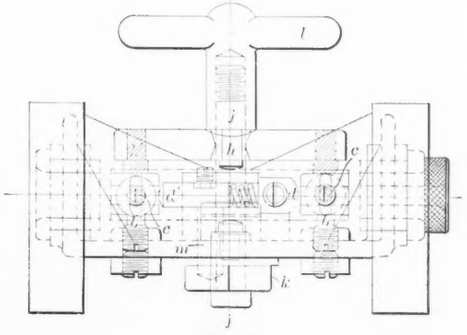


Fig. 4

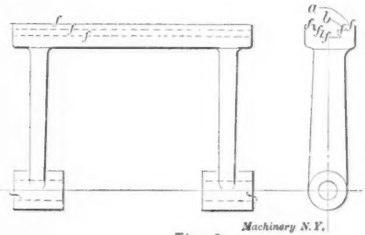


Fig. 3

Jig with Equalizing Clamping Device for Rough Castings.

In this particular case the drilling was found to be the most convenient operation to perform first. Fig 3 shows the casting with a ¼-inch reamed hole through opposite hubs, and milled at the points indicated by *f*. Figs. 4, 5 and 6 show side, plan and end views of the jig with the work therein. The casting rests on the rigid gage point *b* and two adjustable points b^1 b^1, and is pushed against the two adjustable gage points *c c*, Fig. 5, by the spring *e; d* is a rigid gage point sideways, which takes the thrust of drilling, and the end mill. d^1 is a spring pin which pulls the work against the rigid point *d*, and it also takes the thrust of drilling and end milling. The clamp *a* has three pins *h*, h^1 h^1 which are in line with gage points *b* b^1 b^1, for clamping points. Stud *j* extends through the bottom of jig into the strap *k*, which takes the pull of the hand nut *l*. Strap *k* rests on a solid seat, on one end, and the other end rests on the pin *m*, which is in direct line with the spring pin d^1. The upper end of *m* has a slight angle to prevent the slipping of d^1. Therefore, by screwing down the hand nut *l* the force is transmitted through strap *k* to pin *m*, and thus clamps the work and the spring pin d^1 simultaneously. *O* is a slip bushing, which is also used on the opposite side; *n* is a pin extending through *a* to prevent the turning of the clamp when screwing the hand nut *l*; Fig. 7 is the end mill for facing the hubs; and *D D* are adjustable nuts used as a stop against *O*. As the distance from one finished surface of hub to the other had 0.01 inch limit we had no trouble in getting them inside of that figure.

The milling fixture is shown in views Figs. 8, 9 and 10. This fixture is designed for two positions at right angles, or in other words, there are two separate operations to be performed, one from each base *A* and *B*, Fig. 10. The reason for this is that when the fixture is set up on machine platen, on base *A* (as will be seen in operation) a gang mill is used which furnishes surface *a* and *b*, Fig. 3, and roughs out the slot for the dovetail. Now, if this operation were performed in the other position *B* (*B* is the base the fixture stands on when finishing dovetail slot) it would be necessary to make these cuts do the same amount of work that is done with the gang mill in one; therefore it is readily seen that it makes considerable difference in cost of piece what kind of cutters are used. The casting is located from the shaft hole by the stud *C* and spring pin *D*. The idea of a spring is that it has a certain pressure not great enough to spring the casting, but sufficient to push the pin into the hole and the work against the shoulder on *C*. The casting rests on rigid gage point *E* which has the same relative position to fixture as *d*, Fig. 5, has to jig. The center clamp *F* forces the work against the rigid gage point *E;* the two end clamps *G* and *H* are made to float and locate to casting and are locked in place by *J* and *K*. *M* is a gage for setting the cutter. The numbers on the screws indicate the order in which they are to be screwed up. Fig. 11 is the bevel cutter for finish-milling dovetail slot or rack seat.

* * *

MAKING DROP FORGING DIES.

C. W. SHELLY.

Young machinists, who have never seen drop forgings made, may be interested in the following general description of the work:

The dies are made of .45 to .60 carbon steel, and are, usually, from 5 to 8 inches thick. Fig. 1 gives a general idea of their appearance when finished. They are marked *T* and *B* (top and bottom) to prevent their getting mixed up in the laying out. The front and left-hand sides are squared up, and from these sides the center lines of the impressions are laid out and the dies set up when ready for use. The edger, or breaking down impression, is on the right-hand side of the die. It is for breaking down the rough heated stock into something like the shape required, before it goes into the finishing die. Sometimes a separate breaking-down die is used. The heaviest part of the forging is always nearest the front. In deep dies, shapes which show parallel sides on the drawing, are given from 5 to 7 degrees taper on each side, to prevent the forging from sticking in the die. For machining the forging 1-32 inch is usually allowed, and for shrinkage, .012 to .015 per inch. When the dies are finished a

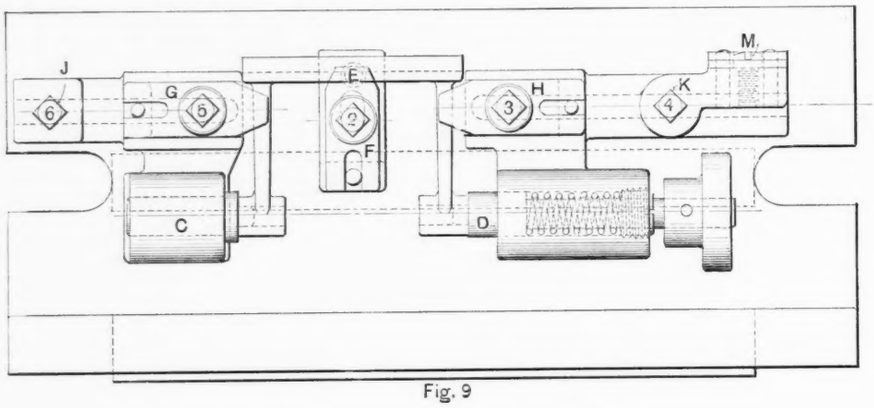


Fig. 9

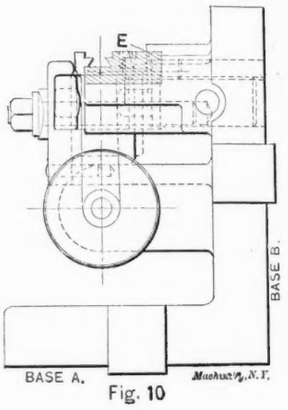


Fig. 10

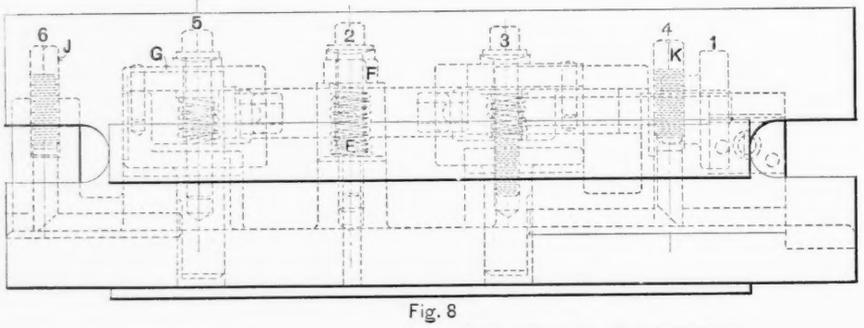


Fig. 8

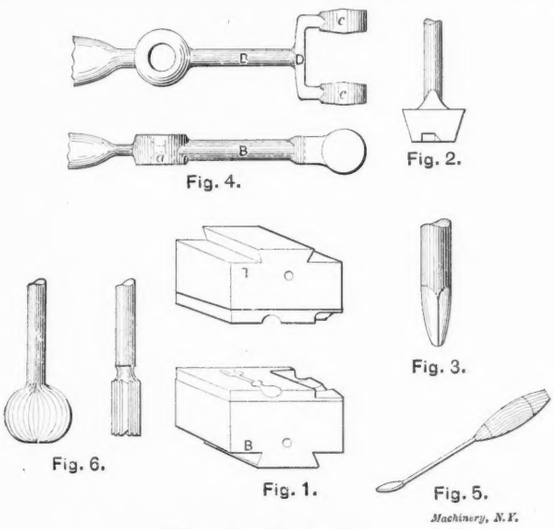
Milling Fixture for Rough Castings.

Fig. 11

C. W. SHELLY was born at Berlin, Ontario, Canada, 1879, and received a Canadian high school education. He served an apprenticeship with the Canadian General Electric Co. at Peterboro, Ont., and has since worked for the General Electric Co., in Lynn, Mass.; the Richmond Electric Co., the Stanley Electric Co., the Hope Mfg. Co., J. H. Williams & Co., etc. He is a tool, die and jig maker, and is now working as a die-sinker on ornamental work.

specimen casting of lead is made in them for ascertaining whether or not they will give the desired result.

The round portion of the impression is sunk first. Swinging the die blank in a lathe, when there is much stock to remove, is a convenient method. In J. H. Williams & Co.'s drop forge shop a cast-iron bolster, for the lathe faceplate, is used. This bolster has a web on its back, which fits the slot in the faceplate. The face of the bolster has a dovetail slot, which is identical with those in the hammer, and is at right angles to the web on the back. By this means a circle is quickly trued up. When the round portion is under 1½ inches in diameter, a profiling machine is better adapted for the work, using the half-round cutter shown in Fig. 2 to finish with, after roughing the stock out with a two-lipped cutter similar to Fig. 3. The half-round cutter is very useful, being strong, easily made, and is easily ground by hand. The one illustrated in Fig. 2 leaves a point in the center of the impression, for spotting the center of the boss on the forging. A die for forging a ball is sunk with a two-lipped spherical cutter. If there is to be a large hole drilled in the forging a plug is left, when sinking, or is afterward inserted in the die to lighten the forging at that point, as is shown at *a*, Fig. 4. This plug should have a taper of 15 degrees on each side, and the top well rounded. In making the dies for forging the piece illustrated in Fig. 4, the round portion, *B*, can be machined out after the part, *D*, is sunk. This may be done with a spherical cutter. In one shop in which I worked a patented attachment for the die-sinker is used, by means of which a cutter can be sunk to its center in the work. The cutter is held in the fixture on a short arbor between half-round centers, around which the cutter is rotated by means of a rawhide gear. The teeth of gear engage the back of the teeth of the cutter. This is only used for finishing. Parts *c c*, in Fig. 4, could be done with this device. It saves time, makes an accurate, clean job and does work that would have to be typed out, *i. e.*, sunk by hand. Some circular impressions are sunk in the milling machine, using one long half-center, and a forming cutter with a small shank, a groove being first cut to clear the shank. The parts *c c*, Fig. 4, would have to be typed in most shops. A type is a hardened steel template, of the size and form that the impression is to be, with the top left soft to prevent the steel from flying when struck with a hammer. Portions of the die that cannot be machined, owing to their irregular shape, or the lack of shop facilities, must be sunk by hand. This requires especial skill with the hammer and chisel, scrapers and gravers, as well as a good eye for judging form. The chisels must be ground to the proper angle on the cutting edge, for chipping the curved surfaces and awkward corners. Scrapers may be made of various shapes, to suit the requirements of the work. One of the most useful is the three-cornered scraper, with two edges rounded; the third, being the cutting edge, is left sharp and is curved toward the point. Another handy one is shown in Fig. 5. It is leaf, or heart-shaped, and is convenient for getting at small curves and corners, especially those at the bottom of the impression. The type is covered with a thin coating of Prussian blue, or red lead, and driven into the die from time to time, as the work progresses, and the high places worked down until the correct form is produced. For the fillets and small corners, a graver or scraper is made from Stubb's steel drill rod, of the desired radius. To save room in the tool-box, a 3-16 or ¼-inch rod may be threaded on one end, and these scrapers fitted to it. A hole is drilled in the cutting end to save time in grinding. The scrapers leave small ridges in the work, which are filed out with riffles, or bent files. Some impressions are polished with a soft pine block and powdered emery, but this is not the usual practice. When the impressions are worked out to the lines a lead casting is taken to see where they need matching or evening up. The lead is tested for size, and if all right, a half-lead is taken from the top die, to be used as a template in laying out the trimming dies, that is, in shops where sheet metal templates are not used. If the lead is overheated, or is heated too often, it will not flow freely and chills before the impression is filled. Powdering the impression with chalk causes the lead to flow freer



Making Drop Forging Dies.

The edger, or breaking down form, on the right of the die, is made from 1-16 to 3-16 inch smaller than the horizontal cross-section of the forging, and has no abrupt shoulders or curves. The idea is to get the heated stock smaller in width than the finishing impression, so that the bottom of the impression strikes the stock first, and spreads it to the sides, filling the die. Cast-iron dies are also used for breaking down heavy work.

The flash, which is a recess .015 to .025 inch in depth, and about ⅞ inch wide, milled around the outline of each impression, allows the surplus stock to escape from the die. This surplus is afterward trimmed off in the trimming dies. The top die, also, has a groove about 1-16 inch in depth, milled around the impression, ¼ inch from the edge. The gate for clearing the stock tapers gradually toward the front from the impression so as not to weaken the die at that point.

In dies for making small forgings in large quantities there are several impressions sunk, one of which is used for a rougher, and should be about 1-32 inch narrower and deeper than the finishing impression. Some dies have to be interlocked when difficult shapes are to be forged, that is, the faces have to be shaped to suit the offset in the forging. Care must be taken to have the interlocking parts high enough so that the dies will not glance off when striking the stock, and making an imperfect forging. When the face of the dies is curved special cutters are made, similar to those in Fig. 6, for surfacing and flashing. As a guide for machining curved impressions, some mechanics transfer the lines to the side of the die blank and lay out the curve there, then clamp a surface gage to the profiling machine, and with the needle set to the face of the cutter, work out the stock by following the lines with the needle point. Dies for forging gears, or similar work, are finished with a broach having the teeth machined in it, which is then driven into the die.

Drop forge die-sinking, on the average, pays better than toolmaking or machinist's work. It requires, I think, more manual skill and, often also, more "jackass" power, but not such a general mechanical knowledge as is necessary in toolmaking. If one becomes expert in sinking dies for drop forgings, and has a taste for the artistic, he can easily work himself into ornamental die-sinking and steel engraving. To follow this up, and become expert at it, requires time and patience, but it holds out the prospect of better wages and better conditions than ordinary tool work.

* * *

A dispatch from Boston says that two fifteen-year-old boys of that city have established a wireless telegraph connection between their homes, half a mile apart. This recalls the fact that thirty days after the appearance of the first published accounts of Bell's invention of the telephone, two New York boys had built and were successfully operating an experimental telephone system of their own. These two boys have since achieved distinction in the electrical field, and have for many years been allied in business. They are Prof. Frank B. Crocker, of Columbia University, and Dr. Schuyler Skaats Wheeler.

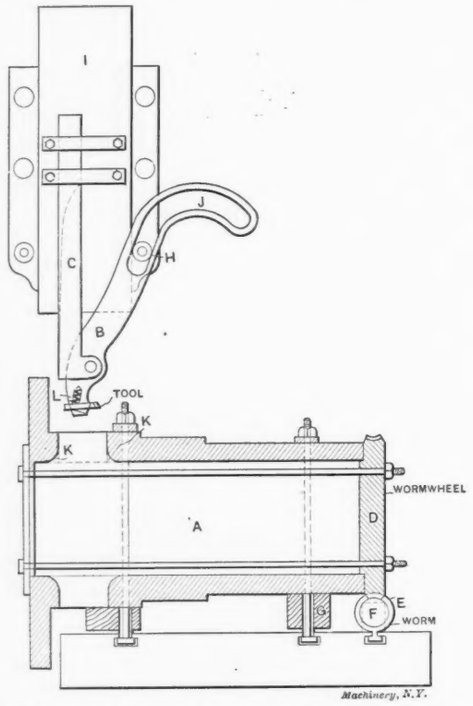
LETTERS UPON PRACTICAL SUBJECTS.

RADIAL SLOTTING ATTACHMENT.

Editor MACHINERY:

I send you a sketch of a radial attachment for a slotting-machine that I made for cutting the arcs marked *K* in the breech bushings of the 15-inch coast defence "dynamite" guns made by the Dickson Mfg. Co., Scranton, Pa., for the government. The first bushings were made of bronze and in these the arcs were cast in, but after trying the guns it was found the metal in the bushings would not stand the test, and they were replaced by the best gun steel. In these the openings were cored straight through, as shown by dotted lines. When the bushes were turned and faced it was found the parts *K* could not be chipped or cut to the required radius by any means at hand in the shop. I then devised the attachment here shown.

A is the bushing, *K* is the part to be cut to a radius of about 2 inches, the openings being about 5 inches by 2½ inches wide. Both ends of the slots had to be cut as shown, and there were about ten slots in the circle. *G* shows wooden blocks made to fit the outside diameter, with a piece of sheet iron tacked on the inside so the bushing would turn freely when screwed down with the clamps. *D* is a wormwheel made fast to the back end of the bushings, and a bracket marked *F* is screwed on the table to hold the worm in place. The worm *E* was turned by means of a hand wheel, not shown, to give the circular motion



Radial Slotting Attachment, Working on Dynamite Gun Bushings.

while the cut was fed in by the screw in the table. The bar *C* was forged from machine steel about 2 inches square and was milled out at the bottom to fit the radial bar *B*; it was also cut out as shown by the dotted lines above, so the bar would fold into it when at the bottom of the stroke. The slot *J* is formed so as to give the proper radius to the cutting tool when rounding *K*. The bar *B* was made about ⅞ inch thick by 3 inches wide and the cutter was ⅝ inch by 7-16 inch with a 5-16 inch pivot pin. The slot in the bar was made so that the tool could relieve itself coming back by compressing spring *L*, which forced it again into position. *H* is a stud with a roller, nut and washer put in place of one of the bolts in the head of the machine; when the holes on one side were finished, all that had to be done was to change the stud to the other side, turn the attachment over and proceed as before.

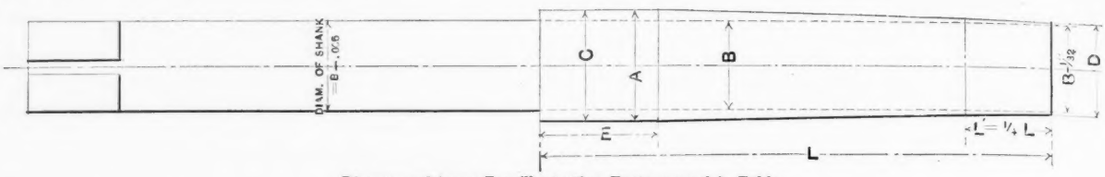


Diagram of Acme Tap illustrating Factors used in Table.

I think that the description and sketch will make the scheme plain and simple to every mechanic, but would add that, of course, a right and left tool was used to cut out the corners.

Plainfield, N. J. D. LINDSAY.

ACME TAPS IN SETS.

Editor MACHINERY:

The table given herewith, on Acme taps in sets, is one which I think will be very much appreciated by many of your subscribers. The formulas, I believe, are correct both as regards theory and practice. I have tried several sets of Acme taps made as per these instructions, and they have given me more satisfaction than any other set of Acme thread taps I have ever tried.

No. of Taps in Set.	Tap.	*C*	*D*	*E*
2	1st	$B + (A - B)\ .65$	$B + .01$	$.125\ L$
	2d	A	C on 1st tap $- .003$	$.25\ L$
3	1st	$B + (A - B)\ .45$	$B + .01$	$.125\ L$
	2d	$B + (A - B)\ .8$	C on 1st tap $- .003$	$.17\ L$
	3d	A	C on 2d tap $- .003$	$.25\ L$
4	1st	$B + (A - B).4$	$B + .01$	$.125\ L$
	2d	$B + (A - B)\ .7$	C on 1st tap $- .003$	$.17\ L$
	3d	$B + (A - B)\ .9$	C on 2d tap $- .003$	$.20\ L$
	4th	A	C on 3d tap $- .003$	$.25\ L$
5	1st	$B + (A - B)\ .37$	$B + .01$	$.125\ L$
	2d	$B + (A - B)\ .63$	C on 1st tap $- .003$	$.125\ L$
	3d	$B + (A - B)\ .82$	C on 2d tap $- .003$	$.17\ L$
	4th	$B + (A - B)\ 94$	C on 3d tap $- .003$	$.20\ L$
	5th	A	C on 4th tap $- .003$	$.25\ L$

Table giving Proportions of Acme Taps in Sets.

Referring to the cut, the length *L* is indeterminate, as it is governed by four factors, which vary according to the work, viz.: diameter of tap, pitch, length of nut to be threaded, and the material to be tapped. But whatever length of *L* is chosen, if made according to the formulas given, every tap in the set will have the same proportion of work to do as the others; the user will have a well divided set of taps no matter how long or how short the length is made.

A = actual diameter = nominal diameter + 0.02 inch.

B = root diameter = nominal diameter $-$ ($\frac{1}{\text{no. of threads}}$ + 0.02 inch).

The values of *C*, *D*, and *E* are given in the table. The length of *L′* is ¼ *L*, and this refers to the first tap only. The end of the first tap is reduced in diameter, as indicated by the dotted lines, so that it will catch the thread without reaming, which

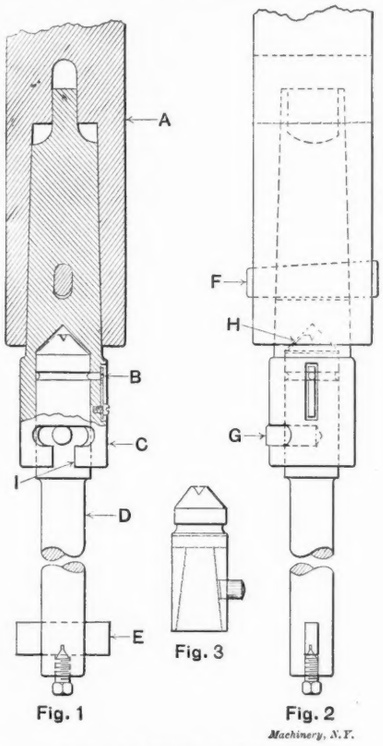
is always the trouble otherwise. With the other taps of the set, of course, this is unnecessary, as the first tap makes the thread deep enough for the following or second thread to catch the lead. In other words, the first tap of the set is made taper in the grooves at the root of the thread for a length of about ¼ *L* to prevent reaming and make it catch the lead easier than would otherwise be the case. A. L. VALENTINE.

Hartford, Conn.

FACING BAR HOLDER.

Editor MACHINERY:

The facing bar holder shown herewith is one of my own design and I believe is new. I find it very good for certain work. The work that I designed the tool for is back-facing boring mill housings, which have to be drilled bottom side up. Its advantage over the ordinary bar with retaining key slot is that the straight bar, *D*, is much cheaper to make, and much easier to change. On a job which requires a variety of bars to face different size holes, considerable time is saved in not having to knock out the retaining key, *F*. Instead bar *D* is disconnected by turning it backward a short distance and



Facing Bar Holder for Drill Press.

slipping it endwise. Again it has the advantage that in case the bar is broken and another one has to be made, the drill press does not have to stand idle while the toolmaker is fitting a new bar in the socket and to the key *F*. The reason for the bar *D* being pointed at the upper end at *H* is to lessen the cost of making; an ordinary drill can be used to drill the socket, and the recess does not have to be squared out in the bottom with the taper end on the bar. The spring and plunger *B* is merely to hold the bar up in place in case the driver pin *G* should become turned backward, so as to be over the center of slot *I*, as sometimes happens when the drill press spindle is reversed.

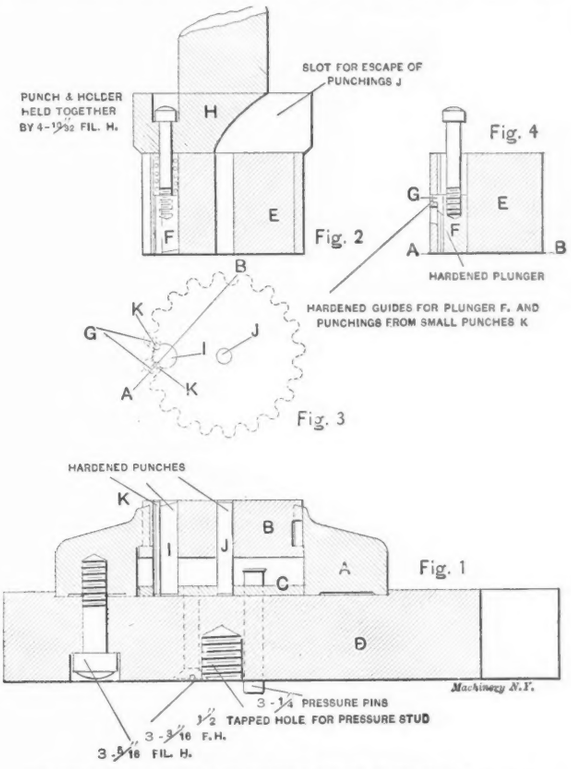
The device is made still more effective for drilling and back-facing holes, say 1½ to 2 inches in diameter, by using straight shank drills with the shanks finished in the same manner as the boring-bar holder. These drills can be exchanged with the boring bars without removing the taper collet. Or in case that is not desirable, collets like that shown in Fig. 3 may be made and used with the drill, the drill and collet being disengaged together. All parts are made of machine steel except the driver pin, *G*, which is made of drill rod hardened and temper drawn to a pale blue. B. M. WELLER.

Franklin, Pa.

PUNCHING DIE FOR MAKING LABELS.

Editor MACHINERY:

Being obliged to get up a set of tools for the cheap manufacture of labels, Fig. 5, I built the following illustrated compound punch and die, one of the requirements having been the use of a single-action press and the production of the piece, Fig. 5, in one operation. As will be seen in Fig. 5 it was necessary to cut the blank, pierce three holes and split the stock between two of the smaller holes on a 5-32-inch radius



Punching Die for Making Pasteboard Labels in Single-action Press.

to allow the enclosed material to be deflected for the insertion of an endless loop. The flap was then bent back into place and secured by a small gummed label pasted over the juncture.

Fig. 1 shows the die, the first part to finish being the cutting ring, *A*. The corrugated cutting edge was made by dividing the circumference into an equal number of parts and drilling every other one, the remaining stock being filed up, with

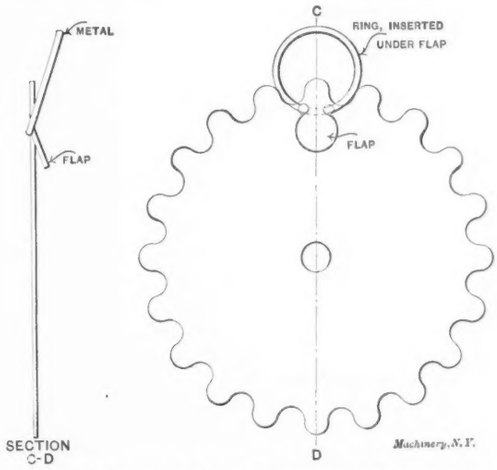


Fig. 5. Label showing Method of Attaching Ring under Flap.

hardly any clearance, to an arc of a circle having the same diameter as the drilled holes, thus producing the outline as seen in Fig. 3. The cutting ring was then hardened and ground on the base (which was slightly recessed) and up a short distance on the outer circumference where it fits the

cast iron die plate, *D*, Fig. 1. It was also ground on the cutting edge, which was beveled about 15 degrees.

The main punch, *E*, Fig. 2, was now worked up and finished by shearing it through the cutting ring, *A*.

Pressure plate, *B*, Fig. 1, was turned up with a 5/8-inch annular groove 1/8 inch from the lower edge and deep enough to clear the inside points of cutting ring, *A*. It was then inserted from below into *A*, and cutting edge scribed off and worked up.

Punch holder, *C*, a 1/8-inch steel disk, was next clamped to the plate, *B*. The two largest holes were drilled and reamed through both and then it was used for a drilling jig on the punch, E, after which the largest hole was plugged with same quality of steel, to prevent drill running, and holes drilled for the two smallest punches, *K*. The pressure plate, *B*, was now used to drill the small holes in the punch, *E*, which had also been plugged the same as plate, *B*. The short plug used in the pressure plate, *B*, was used as the plunger, *F*, Figs. 2 and 4, and the plug used in the punch, *E*, Fig. 2 is the long punch, *I*, in Fig. 1, with the top faced off on an angle to enter the main punch, *E*, which acts as a die, splitting the stock to the small holes previously punched by punches, *K*. Plunger, *F*, is faced off to the same angle as punch, *I*, but not quite up to the edge of the small holes which form the piercing dies. The punchings are expelled through the side of the punch, *E*, by the agency of beveled guides, *G*, Figs. 3 and 4.

Plunger, *F*, Fig. 4, was kept from turning by two right-angle guides, *G*, set into small holes above the discharge holes in the punch body, *E*, from the inside, the plunger when in place keeping them from working out. The guides, *G*, were beveled to facilitate the expulsion of the small punchings from *K*, Figs. 1 and 3.

The punches, *K K I J*, were riveted over in punch plate, *C*, Fig. 1, the tapped holes of which were spotted by using die-plate, *D*, for a template.

Allowing the punchings from *J* and *K* to work up through the punch is a decided advantage, since there is no need of cleaning out the scrap from the finished punching, as happens when using strippers, which force the stock back into place. This saves considerable time in assembling on this class of work.

What may be new to some readers is the use of compressed air for carrying away the work after punching, in lieu of gravity, as on the inclined presses. It was successfully made use of in producing the above article on the upright press. The air was compressed on the down stroke and allowed to strike the face of the die on the up stroke, thus carrying the article, which was light, aside.

PAUL R. WERNER.

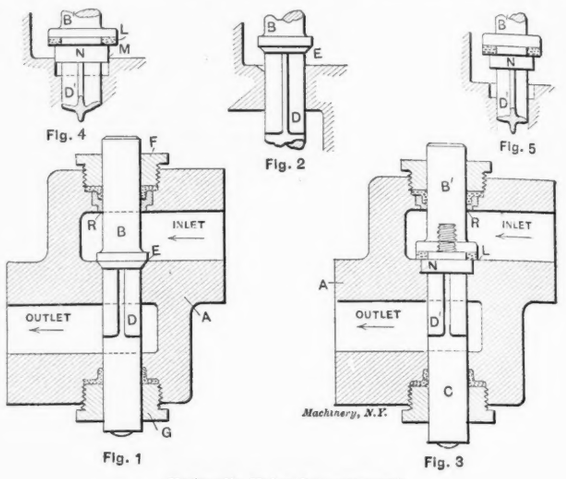
Philadelphia, Pa.

HYDRAULIC VALVE IMPROVEMENT.

Editor MACHINERY:

The illustrations herewith show a hydraulic valve improvement which has proven very satisfactory. The metal-seated valve usually, or rather, I might say, often employed, is shown by Fig. 1. The inlet and outlet are marked, and *A* shows section of the valve body. *F* and *G* are the stuffing-boxes which hold the leather packing rings in place. *B* is the stem cut away to leave only cross ribs at *D*, thus providing water passages when *B* is raised off of the seat *E*, as shown in Fig. 2. As shown, the valve seat is made solid with the body of the valve, but in actual practice this would be separate in order to cheapen repairs. Valves of this style are used in our present installation with water under a pressure of 1,500 pounds to the square inch, and in spite of extreme care taken to keep grit and dirt from the water by filters, etc., we experience more or less trouble continually from the cutting of the seats. The velocity of the water, of course, is at times very high when the valve is open a small amount. Dirt and rust on the pipes, etc., will then quickly groove and destroy a ground brass seat.

To do away with the necessity of grinding the seat and reduce or rather eliminate the leakage when seats become worn or grooved, the style shown in Fig. 3 was adopted. The only change in the design was directly at the valve seat. A leather ring *L* was inserted, which covers the seat joint when the valve is closed. The seat in the body of the valve was then recessed, and the valve stem made to fit fairly tight, as at *N*. Fig 4 shows the valve stem slightly raised and illustrates the use of the part *N*, which as shown, tends to practically keep the valve closed until the leather ring *L* is far enough removed from the edge of valve seat of body to be clear of the cutting action of any dirt carried by the water. As the part *N* does not exactly fit the valve body, a certain leakage will take place as soon as the leather ring is lifted at all, but this amount is so



Hydraulic Valve Improvement.

slight that there is no serious wear on the leather, and its life is, under average conditions, equal to the regular valve seat shown in Fig. 1, and, in addition, has a further advantage of being easily and cheaply replaced.

R is a loose ring which can be removed to allow the larger part of stem *B* to pass.

W. T. SEARS.

Harrisburg, Pa.

ACCURATE JIG MAKING.

Editor MACHINERY:

There seems to be a misunderstanding between Messrs. Shailor and Gordon regarding accurate jig making and if you will allow me the space I will express my views on the subject.

In the first place, I infer from Mr. Shailor's article that his description was intended solely for very accurate jig making. On the other hand it appears to me that Mr. Gordon's method of jig making was intended for jigs such as are used in the average shop. If such is the case it simmers down to a simple misunderstanding between above named gentlemen. But if Mr. Gordon really places the drill-press plan on a par with the button method as described by Mr. Shailor, I have a few words to say regarding the method. The subject is an interesting one; in this case the argument should be carried to the end, for the benefit of the younger readers who accept a statement as truth because it appears in a mechanical magazine.

I have knocked around the country quite a little and have made jigs for producing the recognized standard watches of the country but was compelled to use a more accurate machine than a drill-press. Mr. Shailor enumerated ten chances of error that are presented when employing the drill-press plan, but any toolmaker accustomed to fine work can enumerate ten more chances. Therefore a toolmaker using Mr. Gordon's method stands but one chance in twenty of producing an *accurate* jig. I have in mind a watch factory where the limit on the finished product of a jig is 0.0001; it is obvious that the jig must be almost absolutely correct. For an illustration let us suppose that a jig is assigned to a toolmaker, said jig to produce the plates of a stop-watch. For the benefit of the readers not acquainted with the movements of a stop-watch I will say that there are three wheels in each watch about 0.3 inch diameter that operate the split-second hand. The teeth on said wheels are so fine that they can barely be observed with the naked eye. Let the reader imagine that the job was assigned to him and then seriously consider the drill-press plan for producing the jig!

Mr. Gordon admits the chances for errors are in evidence and proceeds to explain how they can be overcome, but we all know the fact remains that the chances are there. The more chances there are for error the more cautiously a workman must proceed and a greater number of obstacles must be overcome before the workman can make one cut on the jig. It needs no argument on this point to convince the reader that the best method is the one that has the least number of chances for inaccuracy to creep in. Mr. Gordon has the assurance that the drill continues straight clear through the work owing to his long practice. He says if it were not possible to drill straight that we would not have gun barrels, etc. For the enlightenment of Mr. Gordon, would say that gun barrels are not drilled straight through the bar. But the hole is drilled through a large bar and the barrel is then turned to size, using the hole for centers. After turning to size the barrel is straightened by skilled workmen with a hammer in the same manner that we would straighten a crooked nail. Mr. Gordon also states that if a drill is started straight and is not crowded and encounters no blow-holes or uneven density of metal it will continue straight. This remarkable statement is equivalent to telling a teacher that if a person had two dollars and spent one there would be one dollar left. The facts are that blow-holes are encountered, the drill is crowded and uneven density does cause the drill to change its path. Mr. Gordon closes with the statement that he can exactly duplicate jigs on the drill-press plan. I claim he can not and am of the opinion that all thinking toolmakers will agree with me.

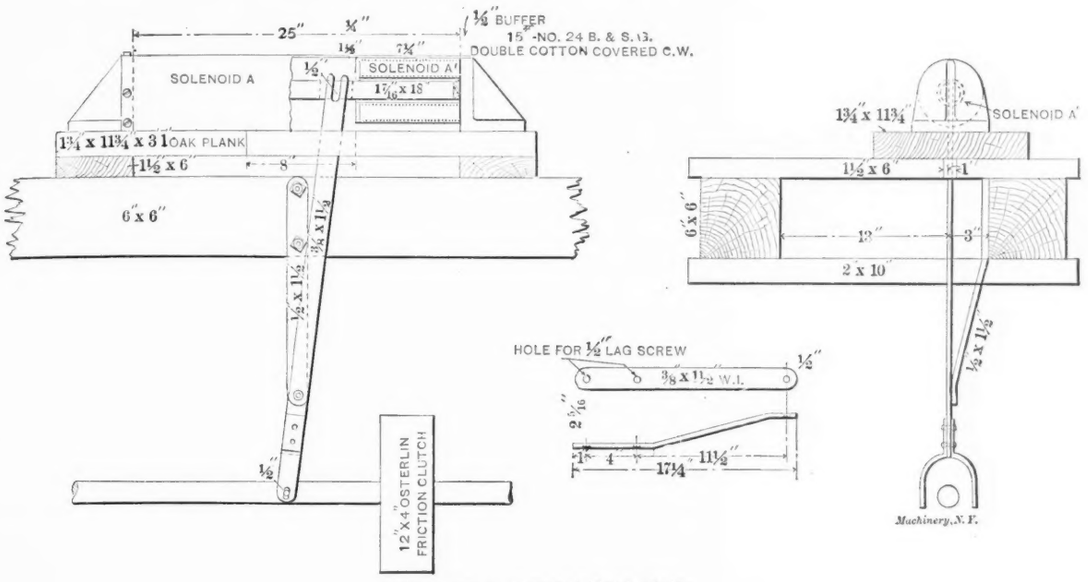
JIG MAKER.

MAGNETIC CLUTCH SHIFTER.

Editor MACHINERY:

The cuts, Figs. 1, 2 and 3, show a magnetic clutch shifting device, and the switch used for operating it. It is used to operate a 4 x 12-inch friction clutch which is belted to the feed of a 36 x 15-inch Gates crushing rolls used for crushing rock. The feed must sometimes be stopped, and it was inconvenient to have an ordinary clutch shifter about, so solenoids were used to throw the clutch instead. The solenoids are operated by a 250-volt lighting circuit and are controlled by the double-throw gravity switch shown in Fig. 3. To start the feed the ball lever is moved to the left to the position marked "feed on" and held there about a minute, and then allowed to fall to its vertical position. To shut off the feed the ball is moved to the right to the position "feed off," and then allowed to fall back to its normal position. One terminal of each solenoid is connected to the same feed wire and the other terminals are connected to the double-throw switch at C' and C''. The middle terminal C connects to the other feed wire. Hence when the ball handle is thrown in one direction solenoid A, for instance, is operated, and *vice versa* solenoid A'. In the middle position no current flows through either solenoid. A number of these double-throw switches are located near the rolls or near other points where trouble may require the stoppage of the feed. The device has been in use for some time and works very satisfactorily.

Desloge, Mo. HERBERT S. GLADFELTER.



Figs. 1 and 2. Magnetic Clutch Shifter.

COMPOUND PUNCH AND DIE FOR STEEL RANGE WORK.

Editor MACHINERY:

I show herewith a punch and die which I designed recently for punching rivet holes in the strips which make the top of a steel range stove. I am of the opinion that this die is constructed and built on different principles than any I have seen in the columns of MACHINERY. If one is looking for cheap production and modern methods, I think this tool will do the

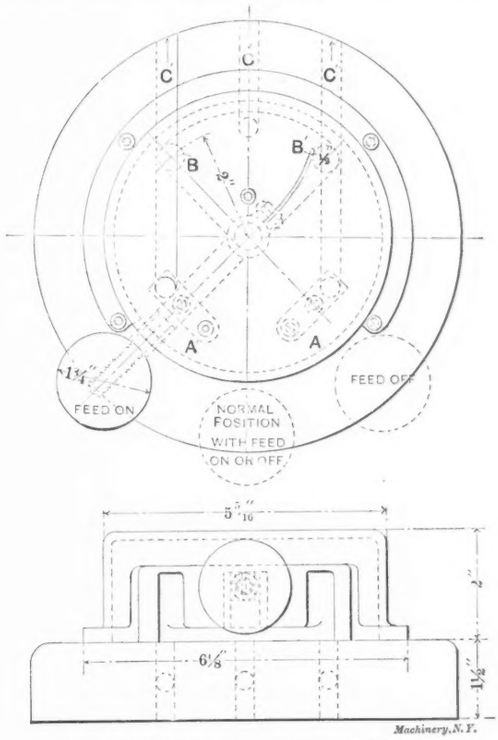


Fig. 3. Switch for Operating Magnetic Clutch Shifter.

HERBERT S. GLADFELTER was born in St. Louis, Mo., April 7, 1882. He has worked for the Curtis & Co. Manufacturing Co., the American Arithmometer Co., the Laclede Gas Company, the St. Louis Smelting & Refining Co., and others. He is a draftsman and machine designer.

business, for it does in one stroke of the press what would require three separate operations, if done one operation at a time. The die is what I would call a twin die, and punches either right or left as the case may be, and in making the die this way I found that it saves three handlings of the work.

Before I describe the tool I would like to say a few words in regard to this tool and what it will do. Of course, everything is done piecework in the shop, and I am figuring this on a piecework basis. We will say there are 1,000 stoves to be made, which means there are 4,000 strips, for it takes four

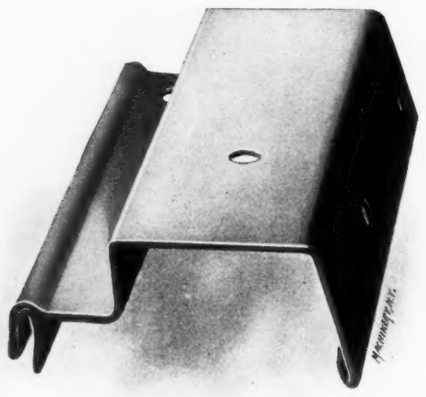


Fig. 1. Sample of Work done on Compound Punch and Die.

strips to each stove, and 20,000 holes to be punched in these strips, and if it were to be done one operation at a time, it would take a man about three days to do the work. This would cost $6.00 and keep the press tied up thirty hours. But the tool I show herewith will do the work in ten hours at a cost of $2.40, and give us twenty hours more use of the press and two days more use of the man for something else. These prices are figured at three cents a hundred holes, and for the tool I show six cents a hundred strips, which makes a difference of

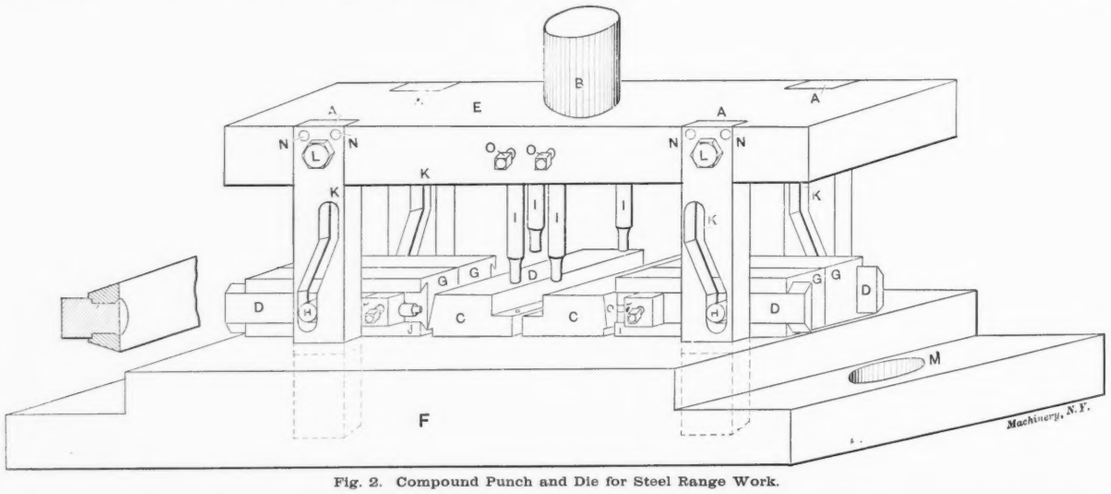


Fig. 2. Compound Punch and Die for Steel Range Work.

$3.60 on a thousand stoves, besides having two days more use of the machine. Since writing the above, 600 strips containing 5 holes each, or 3,000 holes total, have been punched in one and one-fourth hours at a cost of five cents per hundred strips.

The punch holder, or upper half of the die *E* is of cast iron and is mortised out to receive the four pieces *A* which operate the side punches *D*. The shank *B* is of machinery steel and is made a driving fit in *E*. The bolster plate *F* is of cast iron and is fastened to the bed of the press by bolts through the holes *M*. The four pieces *G*, which hold the sliding punches *D*, are of cast iron and are dovetailed; each piece is fastened to the bolster *F* by means of two ⅜ inch fillister screws and two 5-16 inch dowel pins from the under side, which are not shown. The pieces *C* are also of cast iron and are made to conform with the shape of the strip to be punched; they are held in position the same as the pieces *G*, being doweled to make them more rigid, so there is no chance for them to shift and change the alignment with the punches *J*. The punch holders *D* are made of machinery steel, and are made a nice working fit in the pieces *G*. It will be noticed in the sketch that I have left a small tenon on the pieces *D* for the purpose of giving more stock for the setscrews *P*, which hold the punches *J* from pulling out. The vertical punches *I* are four in number and are held in place by means of the setscrews *O O*.

This die was made for a press having a 1¼-inch throw, and the side punches *D* have ½-inch travel; while the ram of the press is traveling 1¼ inches, the side punches move in ½ inch, being operated by the slotted pieces *A*. The pieces *A* are of machinery steel, and casehardened, and are fastened to the piece *E* with ⅜-inch cap screws *L* and two 5-16 inch dowel pins *N* in each piece. The die block *F* is mortised to guide and support the four pieces *A*, and at the highest point they project about ¼ inch into the die block. In this way they are well supported when taking the thrust of the side punches *D*.

After having determined the location of pins, *H*, the slots, *K*, were laid off, giving a horizontal traverse of ½ inch in the diagonal portion which of course gave me the right amount of travel for the side punches. The pins, *H*, are of tool steel, hardened and drawn to a dark straw color, and held in place, as shown in the sectional sketch. The sizes of the holes punched are No. 1 and No. 6 respectively Brown & Sharpe gage, and the material is No. 16 gage. There is also a stripper fitted to this die, which strips the stock from the punches, and acts as an end gage, not shown. There are also two pieces of rubber placed between the punches *I*, which force the work down on the piece, *C*, holding it firmly so that every one is punched alike.

I have tried to show this die as plainly as possible, in the sketch, and also to make the description clear to the readers. In conclusion I wish to say I, for one, would be pleased to see more dies of this nature described, and I hope this may be the means of bringing forth from the readers of MACHINERY a great many tools constructed along these lines.

Lorain, O. W. VAN ORMAN.

SPRING STRIPPERS CONSTRUCTION.

Editor MACHINERY:

I send you sketches of two spring strippers for use on small punches. Fig. 1 was designed to avoid broken punches caused by the spring in the ordinary form (with spring on the inside of stripper shell), getting in under the punch occasionally, and "putting it out of business."

In Fig. 1 punch *A* is fitted into the punch head and fastened by a setscrew as usual. Bushing *B*, is a shell, the upper end of which is a "drive" fit on punch *A*, and the bottom end is a sliding fit over stripper *C;* it has holes for pin, *E*, about ⅛ inch from the lower end as shown. Stripper *C*, is a nice sliding fit over punch *A*, and has a shoulder on lower end to retain the spring, *D*, which is of the ordinary coil type. At the top it has slots through which pin *E* slides, forming a stop and also preventing stripper, *C*, from turning around on

punch, *A*. To set up, remove pin, *E*, stripper, *C*, and spring, *D*. Set up the punch in the die; then when the ram is up place the stripper and spring again in position and fasten with pin, *E*. I have used this construction for two years with satisfactory results.

Fig. 2 is for stripping piercing punches consisting of more than one punch in a single head. I drill four holes (one in each corner) in the punch head as shown, counterboring

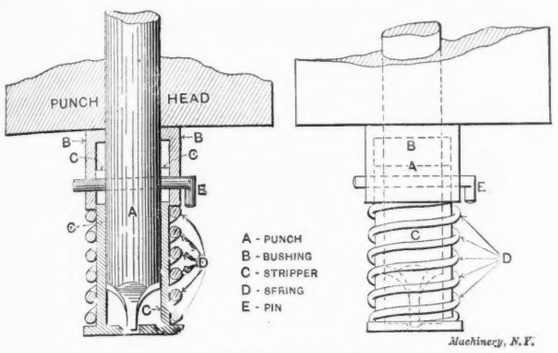


Fig. 1. Sectional and Side Views of Spring Stripper.

nearly through from the top. I insert into each hole a plunger, *A*, and spring, *E*, holding spring, *E*, in position by pin, *D*, and insert a bushing, *B*, in each corner through the holes corresponding to those in the punch head. Now set up punch and die in usual manner, raise ram of machine and place stripper plate, *F*, in position. Plungers, *A*, fit into holes in corresponding bushings, *B*, and are fastened by means of the pins, *C*, as shown. The advantages of this stripper are that it is easily and quickly adjusted, the springs are always

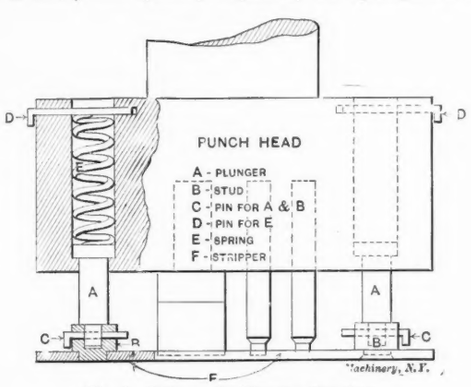


Fig. 2. Stripper for Piercing Punches.

in position and out of the way, and the operator does not have to work against the tension of the springs as he does in the usual form. It is substantial, efficient and a time and profanity saver in setting up, as the operator simply takes it off, sets up the punch, and puts it back again. We have used this design for nearly a year, and have discarded the others.

V. H. MARCELLUS.

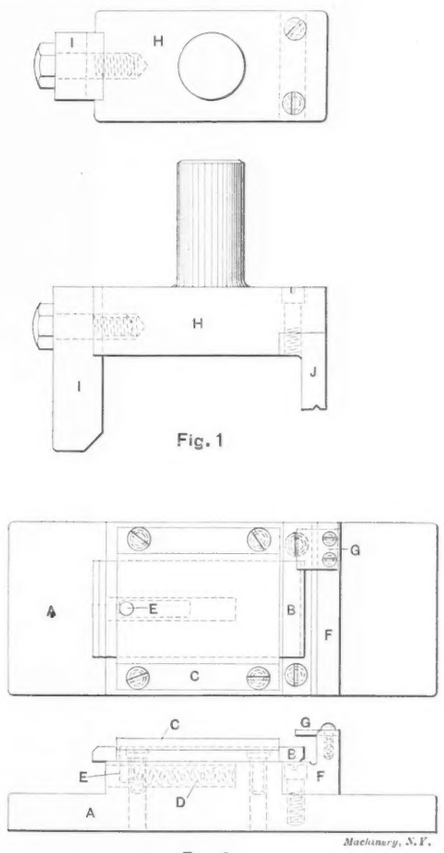
Belvidere, Ill.

SOME HINTS ON BENDING DIES.

Editor MACHINERY:

The illustrations herewith show two styles of bending dies for curling the hinge shown in Fig. 5. Tools and appliances for the making of hinges are about as numerous and vary in design as much as the hinges themselves; they range from the simple punches and dies for blanking and curling in separate operations, to the complicated automatic machines and press attachments, for producing the hinge, complete, with the two parts and pin assembled. The writer has worked on the machines which perform this last-named operation, or multiple of operations, as well as on several types of dies for the same purpose.

The exact design of a die for making a hinge or any other difficult piece of work cannot be selected arbitrarily, but must be governed by conditions. Of course a style of die should be decided upon whose first cost is not out of proportion to the amount saved by its use. The two dies here shown and described are for curling both parts of the same hinges and are merely two differently designed tools for doing the same job. While the diverse plans are for the same requirements, it may be interesting to state that the ratio of production between the two dies was about 5 to 7 in favor of Figs. 3 and 4. This was noted as they were being used at different times in the same press and by the same operator, the press being run at as high a speed as is consistent with good practice. Although these dies are simple in design and construction, there are several points in each where close work is essential to accurate and uniform production, *i. e.*, accuracy of the parts which curve the metal; smooth finish on these parts and care in hardening; to have them as hard as possible, as there is considerable wear at this particular point from the friction of curling. Care must be exercised in the setting up of the dies, to insure perfect alignment with the punch so that when the V on the lower side of the latter engages the upper edge of the blank, it will be held in line with the slot



Figs. 1 and 2. Design of Punch and Bending Die for Curling Hinges, No. 1.

in the die that receives it, otherwise the work will have a tendency to buckle. Moreover, carefully adjust the stroke of the press, to allow it to descend just far enough to complete the curl, and no more. If it comes down too far the work will jam in the die, and difficulty will be experienced in removing it without injury to the die. It is essential that the proper lubricant be used on the blanks, according to the metal employed, and also, that every blank be dipped to eliminate unnecessary friction in the curling action. We have observed from the action of hinge dies of this character, for small work, that there is a very narrow margin between the development of a good and a bad curled hinge, and that it takes very little deviation from the ordinary conditions to make the latter.

When dies for turning out the work under consideration are made of the above types and properly constructed, the results will be all that can be desired. They work well and rapidly and turn out the maximum amount of work before requiring repairs or renewal. It is important for the successful running of these dies that there be no pronounced

burrs on the blanks, and especially so in regard to Figs. 3 and 4; prominent burrs would preclude the use of this type altogether, as the opening to receive the work can only be about .003 inch wider than the thickness of the blanks, consequently, the piercing and blanking die must do good work in order to show final results.

The die, Fig. 2, consists of seven parts: The holder or body *A*, of cast-iron; the slide, *B*, of tool steel, hardened and finished

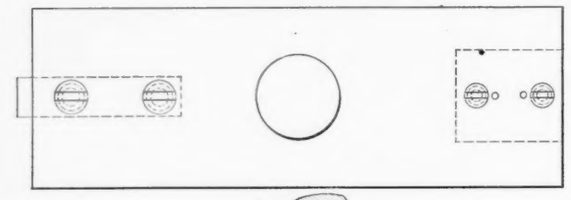


Fig. 3

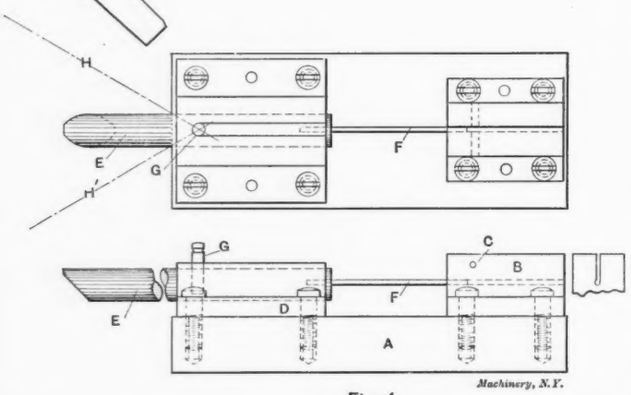


Fig. 4

Figs. 3 and 4. Design of Punch and Bending Die for Curling Hinges, No. 2.

by grinding; the cast-iron cap *C*, secured to *A* by four screws, and holding in place the slide *B*, yet permitting it to have a free lateral movement; the spiral spring *D*, which is for the purpose of moving the slide outward on the upward stroke of the press, by the pressure against pin *E*; the tool steel die *F*, which curls the blank, forming the hinge, and *G*, which is the gage to locate the blanks, and prevents the operator from putting them too far back in the die.

The punch, Fig. 1, consists of the holder *H*, finished top and bottom with one end slotted to receive the cam *I*, which is secured by a cap-screw. The working face of this piece is polished and made as hard as fire and salt water will permit, and engages the corresponding angle on the outer end of the slide *C*, in Fig. 2. Secured by two screws to the opposite end of the punch holder, is the punch *J*, having a small V planed in its lower face to engage the upper edge of the work.

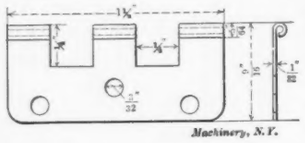


Fig. 5. Sample of Hinge Curled.

When in action the blank is placed in position between the inner end of the slide and the die proper; the punch descending, forces the slide firmly but lightly against the side of the work, and the continued downward movement of the punch performs the operation. On the up stroke the slide is pushed out to its limit by the spring, permitting a free removal of the finished work and the insertion of a fresh blank.

The sketches, Fig. 3 and Fig. 4, illustrate the second die. *A*, Fig. 4, is the cast-iron base, *B* is the die, and *C* is the stop pin. The die is fastened to the base by screws and dowel pins. Mounted in the rear of the die *B*, and fastened to *A* by screw and dowel pins, is the bracket *D*, carrying the sliding shaft *E*. Inserted in the forward end of this shaft is a piece of Stubb's drill rod *F*, the outer end of which is hardened, and fits in the hole in the die. Driven into shaft *E* is a spring post, *G*, to which are hooked two closely coiled springs, their opposite ends being fastened to pins located in the bolster, in such a position as to line the springs at about the angle indicated by the dotted lines *H H'*. On the down stroke of the punch these springs hold the shaft in the position in which it is drawn. The object of the angular arrangement of the springs is two-fold: permitting the cam *L*, Fig. 3, to pass between them, and also, minimizing the possibility of an accident. Should one spring break, the other is sufficient to do the work. The punch, Fig. 3, consists of the holder *J*, steel die *K*, and angle or cam piece, *L*. When in operation the punch descending allows the stripper shaft *E*, Fig. 4, to be withdrawn, by the springs, in time to clear the blank as it is forced down and curled. On the return stroke the shaft is positively advanced, by contact with the angle piece on the punch, ejecting the hinge from the die. This tool had to be, of necessity, operated in a press of the proper stroke to prevent the angle piece *L* raising entirely clear of the end of the shaft *E*. This stripping arrangement permitted a continuous feeding of the blanks to the die, increasing the output over the other punch and die in about the ratio above referred to.

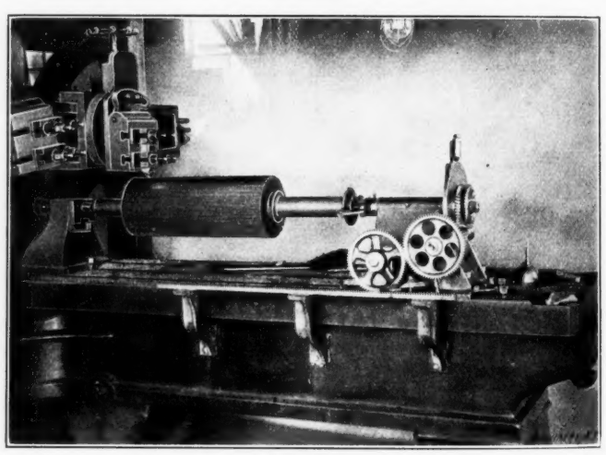
C. H. Rowe.

Worcester, Mass.

PLANING SPIRAL CORRUGATED ROLLS.

Editor Machinery:

We recently had some corrugated chilled cast-iron rolls, all belonging to a feed grinding mill, come into the shop to be re-corrugated or sharpened. If the flutes had been straight, this would have been a simple matter, but as they were in the form of a spiral extending around the roll 1-42 of a revolution per foot in length, or 8 4-7 degrees per foot, they presented somewhat more of a problem. Each roll weighed about 400 pounds, and we mounted it on a pair of Fay & Scott's 20-inch planer centers. On the outer end of the head spindle was keyed a disk carrying an index pin. Outside of the disk and loose on the spindle was a worm gear to which was fastened the index plate.



Planing Spiral Corrugated Rolls.

To prevent undue strain on the index pin when the roll was being revolved, binder bolts were passed through the worm gear extending into a circular T-slot in the disk, and it was of course, necessary to loosen them when revolving the roll by hand to the next corrugation. For revolving this work to obtain the spiral, a horizontal shaft extended out to the side of the planer platen on which was mounted a gear. This gear running in a stationary rack fastened to the bed of the planer gave the proper speed to the roll when the platen was in motion. The extra intermediate gear shown was to change the direction of revolution of the roll, as we happened to have a left-hand worm which was used in place of a right-hand, which would have given the right direction without use of the intermediate gear. We found it necessary to slow the planer down

to about one-third speed, and then tried several makes of high-speed steels before we found one which would cut this chilled iron in an economical manner. W. L. FAY.

Dexter, Me.

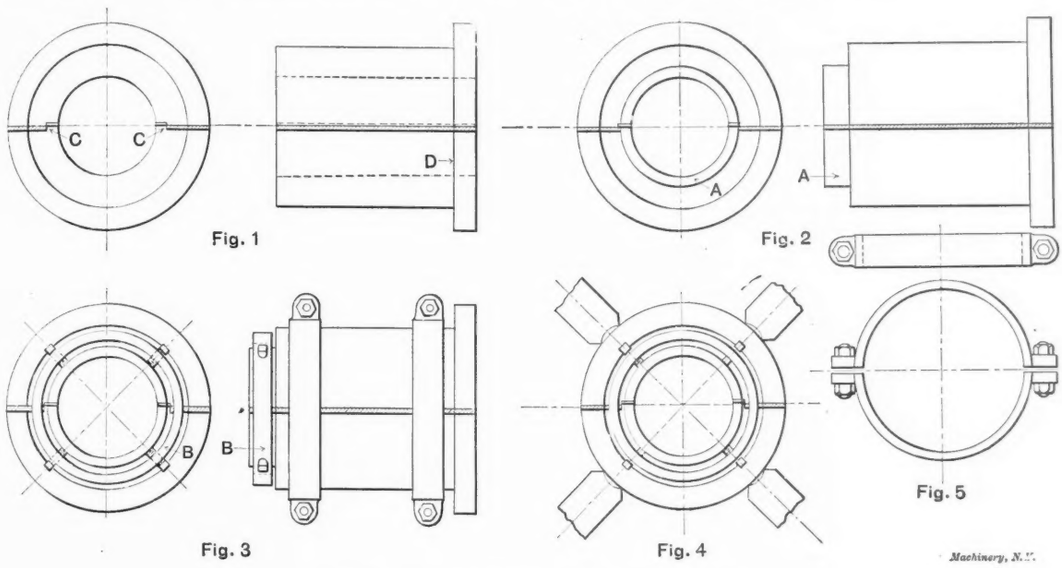
METHOD OF BORING AND TURNING A CAST IRON BUSHING IN HALVES.

Editor MACHINERY:

Some time ago in the shop where I am employed the question came up as to how we could bore and turn the cast iron bushing shown finished in Fig. 1. The bushing is in halves, and is used in the end crank bearings of a two-cylinder vertical gas engine. After some figuring we decided to do the job in the following way:

First, the bushing was cast with the projected ring on the end as shown at *A*, Fig. 2. The halves were then planed in the usual manner, with the shoulders *C C* in Fig. 1. Next we made a steel ring with setscrews as shown at *B*, Fig. 3. The halves of the bushing were then placed together with the proper size shim between; the steel ring was next placed over the projected ring of the bushing and the setscrews tightened. The work was placed in the lathe chuck and centered as shown in the end view of Fig. 4. It was bored and turned and the edge, *D*, in Fig. 1 faced. While still in this position in the lathe two clamps like the one shown in Fig. 5 were slipped on the bushing and tightened as shown in the side view of Fig. 3. The bushing was then taken out of the chuck and slipped on a mandrel. The flange end was turned and the projected ring turned off, this being the last operation and finishing the job. This method of boring and turning the bushing makes all of the surfaces perfectly true with each other.

Dayton, O. A. J. BRUTSCHE.



Method of Boring and Turning Cast Iron Bush in Halves.

CALIPERING THE FIT OF A SCREW THREAD.

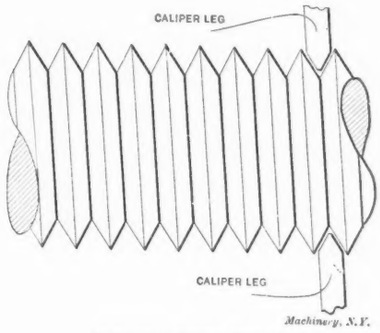
Editor MACHINERY:

The fit of a screw with V-threads is on the incline face of the thread only, and not at either sharp point top or bottom; but I find it to be decidedly common practice among machinists to use a thread caliper which is sharpened to a thin sharp point. This is a mistake, for the reason that in case the thread tool should crumble the least bit or get dull at the extreme point, it leaves a little fillet at the very point at which the caliper is indicating, and then the man is at sea as to the thickness of the thread.

To remedy this evil, I would advise him to take a pair of ordinary outside calipers and file the points to fit a thread tool gage, leaving a slight space flat at the extreme point as indicated by the sketch submitted herewith, thereby avoiding any chance of touching the bottom. Then when the caliper is tried over the work it will be found to fit on the flat incline surface of both sides of the thread, thereby calipering the work just where the bearing surface is. When the thread cutting tool is properly ground the extreme root of the thread will take care of itself. Some men advise making the sides of the caliper points slightly round instead of a fit to the tool gage. By using the above described style of caliper points the lathe man is able to vouch for the accuracy of the fit he is making, just as well by the calipers as he can after he has tried the pieces together. I have found the scheme efficient as will be seen by relating a circumstance which occurred when I was working on the night shift in an engine shop.

When I came in to work in the evening I found standing beside my lathe, nine piston rods to be finished to size (the piston head had been put on and riveted solid). They were 2¼ inches diameter by 30 inches long, and were to have a thread cut up on the end 3½ inches long with 8 threads per inch, which had to be a perfect fit to the cast steel crosshead. The entire rod and head weighed about 150 pounds, while the crosshead weighed 110 pounds. They were the high-pressure heads for a 12- and 22- by 12-inch compound engine. I used the sort of thread caliper above described, in fitting the threads, and found each rod to fit perfectly the first time I tried them into the crosshead. At 12 o'clock at night I had the entire lot completed, every one of them stood their test, and passed the inspection O. K. Previous to the time I introduced these thread calipers, it had usually been one hour's job to fit each thread alone, to say nothing of the finishing cut on the blank or straight portion of the rod. H. E. WOOD.

Pearl River, N. Y.



Calipering Screw Thread.

A COMBINED CUTTING, DRAWING AND KNURLING DIE.

Editor MACHINERY:

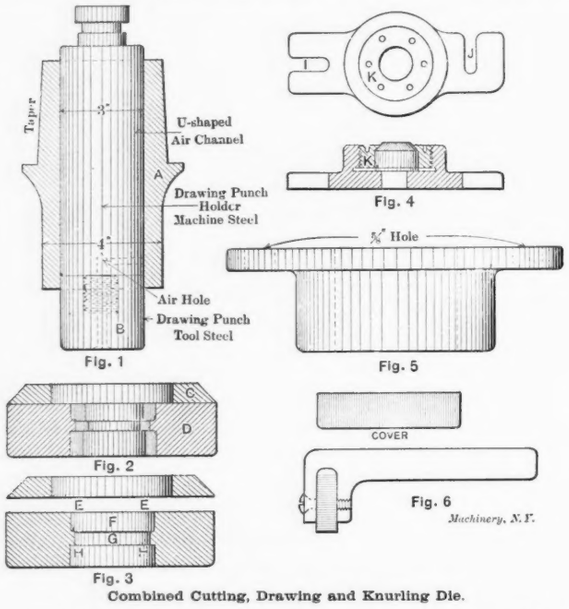
The cut shows a set of cutting and drawing tools used in a double-acting power press for cutting and drawing a so-called knurled cover, in one operation; also a die bed or bolster which is quite a time-saver, and is used in connection with

this set of tools. These tools cut and draw a brass cover 3 inches diameter and ½ inch long—thickness of metal 0.050 inch—which is used on a cylinder-shaped metal box, the outside of the cover being ribbed or milled for convenience in screwing on or off the box.

Fig. 1 shows the cutting punch, *A*, which is 4 inches diameter at the cutting part. It has a taper shank and is made a driving fit in the punch holder, Fig. 5, which is held in the press by two ⅝-inch screws.

The drawing punch, *B*, is made in two parts. The drawing part is made of tool steel and is 3¼ inches long and has a 1-inch tapped hole in the end where it screws on the punch-holder. The punch is hardened and ground, and is lapped smooth to size. The air hole shown not only makes it easier to draw up the shell or cover, but it enables the cover to be more easily stripped from the punch. The drawing punch holder is used for different sizes of drawing punches, and is held in the press by a yoke key, or as some diemakers call it, a U-shaped key, which fits the nipple on the upper end of the holder.

The die is made in two parts, namely, the cutting part and the drawing part. The cutting part is made of tool steel, and is hardened and ground on the top and bottom; it is beveled



Combined Cutting, Drawing and Knurling Die.

on the side to correspond with the bevel on the threaded collar shown in Fig. 4 at *K*. The 4-inch hole is ground and has very little clearance, for the reason that if too much clearance is given it will cause the blank to shift from side to side after it is cut, thereby causing the cover to be uneven in its length.

The drawing part is made as shown in Fig. 3. *F* and *G* are the parts that draw up the ribbed cover after the blank is cut. The mouth of die is rounded, as shown at *EE*, thereby making it easier to force the blank through the die. The diameter of *F* is made 0.020 inch larger than *G*, and it draws up the cover before it is ribbed by *G*. The diameter of *G* is made a trifle smaller than the required size, as the cover expands slightly after having passed through the die. The corners, *HH*, are made sharp and strip the cover from the drawing punch on the upward stroke of the press. Part *G* is ribbed or milled with the knurl shown in Fig. 6.

Fig. 4 shows the bolster for holding the die. The die is held in position by the threaded collar, *K*, which is screwed down upon it by the aid of a spanner wrench having two pins which engage in the holes shown. This bolster differs from the one most generally used inasmuch as it has the slots for the screws running at right angles with each other. When taking the bolster out of, or placing it in the press, the screws need never be any more than just loosened up, while with the other style, one screw must be taken out entirely before the bolster can be removed. When placing this bolster in the press, the slot, *I*, is engaged with the screw on the left, after which the bed is swung to the right until the slot, *J*, engages the screw.

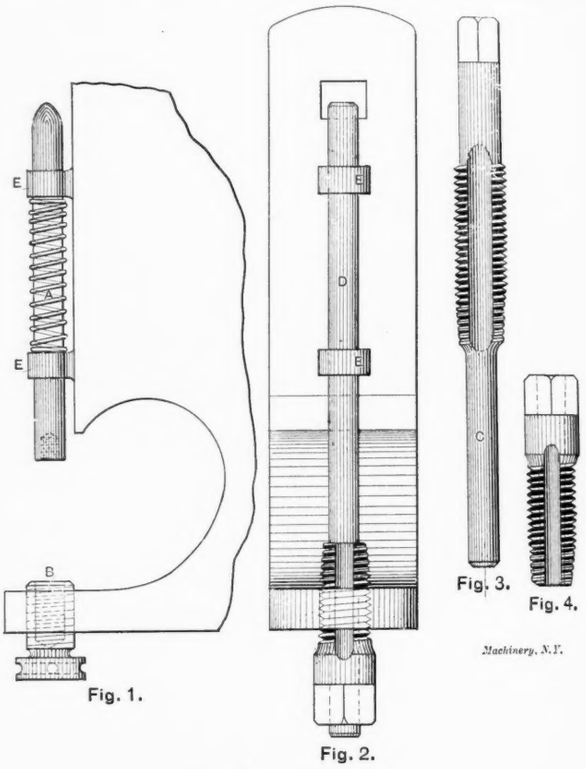
The arrangement used for guiding of the metal, and the stripping it from the cutting punch is not shown, but is similar to those that have been described in MACHINERY from time to time and therefore needs no explanation. The covers are threaded after they leave the press; they are then cleaned and nickeled and are then ready for use.

C. F. EMERSON.

A TAPPING EXPERIENCE.

Editor MACHINERY:

In the accompanying sketch, Fig. 1 illustrates a portion of a machine for setting metal parts in a fabric. *A* is the ram, or plunger, and *B*, is the bolster. Both of these parts carry a die. In tapping the base for the bolster, *B*, we used the tap, Fig. 3, with a pilot pin, *C*, running up through the lug, *E*. It seems as though this should bring the plunger in line with the hole in the base, but it was found on examination



Showing use of Hollow Tap.

that it did not, some varying as much as 1-32 inch, which wrought havoc with the metal parts being set. So the foreman designed the hollow tap, Fig. 4. This tap was bored a snug fit for the bar, *D*, which passed through the lugs, *E*, *E*, and the hole to be tapped, the hollow tap was slipped over it and the hole was tapped. In this manner the tapped hole came in exact alignment with the plunger.

PEDRO RE.

* * *

An error occurred in Mr. L. S. Burbank's article "Table of Spur Gear Teeth Giving Diametral Pitch," in the December, 1904, issue. In the explanation of the table the statement: "As the products of $\sqrt{s}$ and $\sqrt{\frac{2.51}{W}}$ (the loads and velocities) divided by 33,000 give the horse powers, etc.," obviously should have read: "As the products of the loads and velocities divided by 33,000 give the horse powers, etc."

* * *

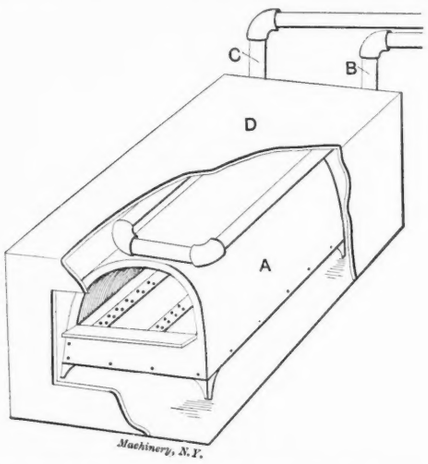
A little kink in the lacing of belts is mentioned by the *Mining Reporter* which makes it easier to thread the ends of the lacing leather through the belt. The ends of the laces should be gently charred over a small flame, a lighted match, for instance, using care that the leather is not burned, and it will be found that the ends have taken a stiffness or rigidity sufficient to enable them to be readily pushed through the holes in the belt.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.
Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

HOT WATER FOR THE TIN SHOP.

Shops using soldering furnaces and not run by steam power, may have hot water in abundance by using this design. It is in practical use and furnishes us with abundance of water, scalding hot. An old style kitchen range outfit is used, that is, a regular galvanized boiler, and a coil of pipe. Referring to the sketch, *A* is the soldering furnace; *B* and *C*, the pipes to and from boiler; and *D*, a sheet iron (1-16 inch



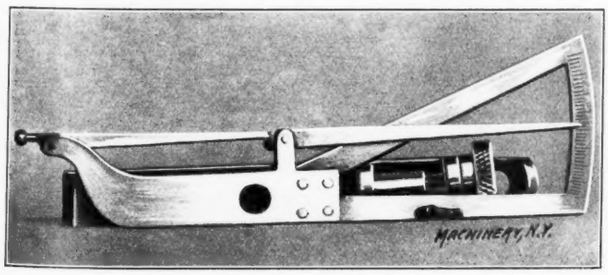
or ⅛ inch thick) covering, lined with thick asbestos paper or fire clay. The furnace is set about 4 inches back of the front of the covering. The bend of the pipes is over the front edge of the furnace, so as to catch the bare flame, escaping from the front end of furnace. All pipes used are 1 inch, except the pipe running from the boiler to hydrant, and this is made ½ inch.

PARK B. SHEE.

Lancaster, Pa.

A SIMPLE INDICATOR.

The half-tone shows an indicator, for testing the truth of work, that I find to be very sensitive and reliable. It is so simple in construction that an apprentice can easily make one for his own use. It consists of a frame supporting two levers arranged in tandem and swinging upon hard steel pivots, a reading scale, a ball, a bolt with thumb-nut, and a holder for use on the lathe. With the bolt the indicator may be screwed to a surface gage, and the frame is of such a shape that it may be easily clamped against any flat surface. Since gravity, and not springs, is relied on to work the lever, the tool must



always be used in or near the horizontal position, but with some special attachments it may be used as a universal indicator, and I use none other in the shop. The ball shown in place is used in truing up work by a hole, a button, a prick punch mark, etc. When truing work by the prick punch mark we use a "wiggler," which is made in two parts, one telescoping the other and provided with a spring for holding them apart. This is preferable to a solid wiggler, because it can compress as the prick punch mark nears the center. The small attachment shown in the illustration is used instead of the ball to test lathe centers, faceplates, large shafting, and all work of a similar nature. The first or short lever is 2.1 inches long over all, the distance from the center of the ball to the pivot being 0.25 inch, and from the pivot to point of contact with second lever 1.75 inch. The long lever is 2.65 inches long over all, the distance from the contact with the first lever to the pivot being 0.11 inch, and from the pivot to pointer end 2.47 inches. The distance between the pivots is 1.86 inches, and the total lengh of the tool is 4.77 inches. The short graduations on the scale represent 0.0002 inch, and the long ones 0.001 inch. The graduations were marked off from actual measurement on the ball point of the first lever.

Great Barrington, Mass. J. MATHIEU.

PIPE CENTERS—KEYSEATING BAR FOR SHAPER USE.

Figs. 1 and 2 show male and female loose head pipe centers for lathe use. The head *A* may be made of either machinery steel or cast iron. The hole is bored taper, and the stem *B* is fitted, and driven in tight enough to allow it to be used as an arbor for turning the head, thus making it true. When finished, two or more steel buttons are made to fill

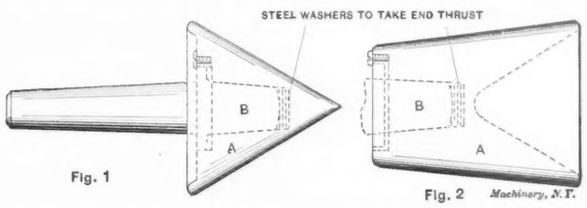


Fig. 1 Fig. 2

the end of the small hole and act as a step bearing to take the end-thrust when the center is in use. Enough buttons should be used to hold the head in position on the stem so there will be no lost motion and still have it turn freely. The pipe center is a tool which is almost indispensable, where all kinds of work are done, to hold pieces being bolted to the face plate, to hold and turn any piece with a hole in it, and many other jobs.

A handy bar for use in a shaper for key-seating may be made like Fig. 3. The tool-post of the shaper having been re-

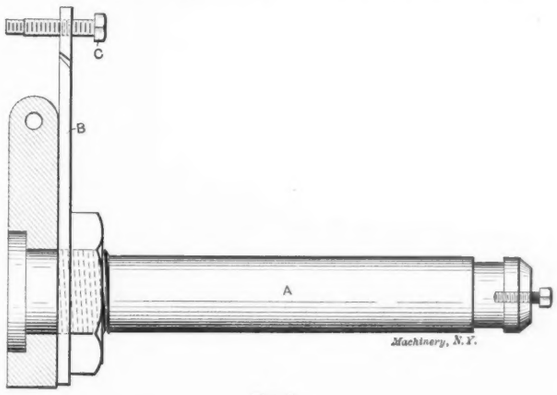


Fig. 3.

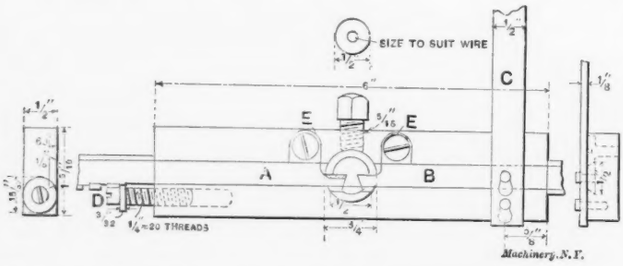
moved, the key-seating bar *A* is placed in the clapper block and a piece of spring steel *B* about 3-16 to ¼ inch thick and from 2½ inches to 3 inches wide is bolted under the nut. The steel spring has a hole a little larger than the diameter of the thread on the bar, and extends high enough to reach a good resting place for the tension screw *C* at the upper end. The outer end of the bar has a hole about ½ inch square for the tool, which is held in place with a setscrew. I made and used a bar of this description in one repair shop, where it is still in use for light key seating.

J. T.

"BOSTON TOOL" FOR MODEL WORK.

The drawing shows a little tool which I made some years ago for an odd job of model work, which was this: I wanted a shaft 9 inches long, 3-32 inch diameter, with bearing on each end ½ inch long and 1-16 inch diameter—rather an awkward job for a 16-inch lathe. So I made the "Boston tool" here described, which I found very satisfactory for the purpose, and I have since made others in different shops where they have

been accepted as the "proper thing" for making little pieces, such as special screws, counterbores, dowel pins, cores, etc., from drill rod and round stock. The large bushing is hardened and ground and may be used on ½-inch work, and bushings fitting it for smaller work. Tool *A* is a regular side tool and *B* is a cut-off tool, operated by the lever *C*, which can be detached by pulling up so the pin heads may pass through the large holes at the lower ends of the slots in the lever. The



collar on the feed screw *D* turns in slots in the bottom of the tool *A*. The tools are made of ⅛-inch by ½-inch stock and are an easy fit in the holder; they are gibbed at *E E*. For the convenience of any reader of MACHINERY who may wish to make himself one of these tools I have put the principal dimensions on the drawing. L. E. MUNCY.

Syracuse, N. Y.

* * *

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

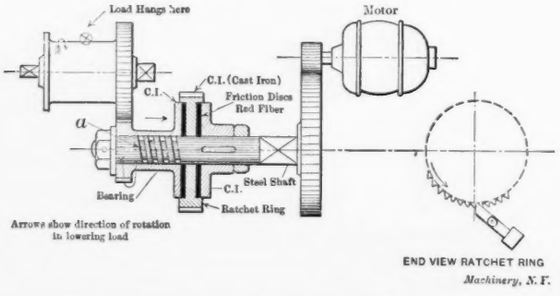
The following queries are referred to the readers:

22. A. R. B.—What is the specific heat of soapstone?

23. H. L.—What is the shrinkage coefficient of plaster of paris from liquid to solid state, at ordinary temperatures? What is its expansion coefficient for heat when in the solid state? At what temperature is the "water of crystallization" driven off?

24. T.U.V.—What is the reduction of strength in ordinary brass when subjected to temperatures higher than normal? For instance, how much thicker is it necessary to make a brass globe valve for superheated steam at, say, 600 degrees F. than for saturated steam at 350 degrees F. in order to secure the same factors of safety, the pressures being the same in each case?

25. R. A. G.—The sketch illustrates the mechanical brake, a well-known device used on electric traveling cranes. Will

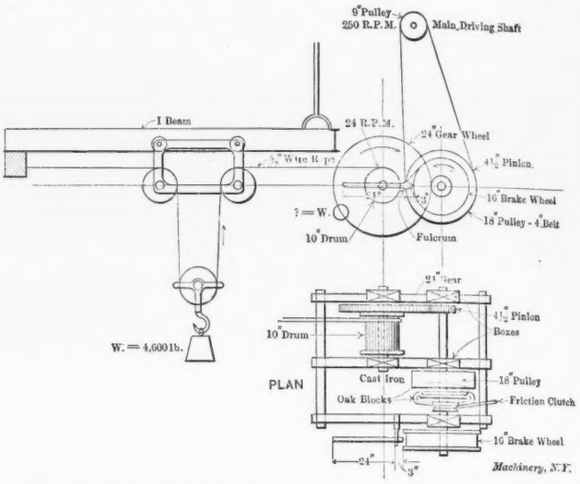


you kindly tell me how to figure the pitch of the screw *a* to hold the load; also the proper pitch which shall require the minimum amount of power to lower the load.

Answer to Question No. 16.

In reply to the inquiry in the December issue for a compound that will coat zinc black for template work, L. M. writes: "Paint will not adhere directly to zinc, as owing to a chemical action, a fine white powder or scale is deposited on the surface of the zinc, causing the paint to peel off. This can be prevented by preliminary treatment, and I feel sure that the following formula will work well: Dissolve in 64 parts of water, 1 part chloride of copper; 1 part nitrate of copper; 1 part sal ammoniac. Add to the above 1 part of commercial hydrochloric acid. Brushing the surface with this preparation will give a dead black coat, and the zinc will be ready for painting in 24 hours."

26. A. P. M.—Kindly give a demonstrated formula for finding the necessary weight to be placed upon the lever of the power hoist so as to sustain a weight of 4,600 pounds with the band brake. The brake is fitted with oak blocks of the usual V-shape working in a grooved cast-iron brake wheel. The load is lowered by gravity, and must be retarded and brought



to rest gently by the action of the brake, because of the delicacy of the work handled, being cores for the foundry. With the mechanism now in operation, I find a weight of 20 pounds on the lever enables us to handle a load of 2,000 pounds nicely and without the slightest jar. A formula submitted by another journal gave the weight of 3½ pounds to sustain the full load of 4,600 pounds.

Answered by Mr. C. F. Blake.

A. This problem cannot advantageously be put into formula shape as requested, but the solution is as follows: The first thing to be obtained is the efficiency of the machine. Formulas for this may be found in MACHINERY, Mar. and Apr., 1903. Lacking definite information as to sizes of pins and shafts, etc., we will assume 75 per cent., which will be quite near the truth if the machine is well built. We must also assume that the weight of the blocks and ropes at the lowest point is included in the 4,600 pounds, since nothing is said to the contrary. We then have 2,300 pounds on each rope, and $\frac{2{,}300 \times 10 \times 4.5}{24 \times 16} = 269$ pounds *net* on brake wheel. Including the frictional loss we have 269 pounds × 0.75 = 201.75 pounds, say 202 pounds on brake wheel at 75 per cent efficiency of machine. Formulas for band brakes may be found in MACHINERY for January, 1901, from which we have:

$$T = \frac{P\,b}{a\,(k-1)}$$ in which

T = weight required.
b = lever arm = 3 inches.
a = lever arm = 24 inches.
k = constant.

Data to obtain k is wanting in the sketch, but assuming the arc of contact to be 270 degrees and the coefficient of friction 0.3 we have $k = 4.11$. Then $T = \frac{202 \times 3}{24 \times 3.11} = 8.1$ pounds weight required. Owing to the variation in the coefficient of friction and the assumed efficiency of the machine it will be well to make the weight somewhat heavier than calculated, say ten pounds, and make it to slide on the lever and fasten with a setscrew, so as to be adjustable. You probably get the results described with the 20-pound weight, but you will also get the same results with a much lighter weight, since the lever and weight must be lifted to lower the load, and a man could lift considerably over-weight without losing control of the load.

MACHINERY AND TOOLS.

A MONTHLY RECORD OF NEW APPLIANCES FOR THE SHOP.

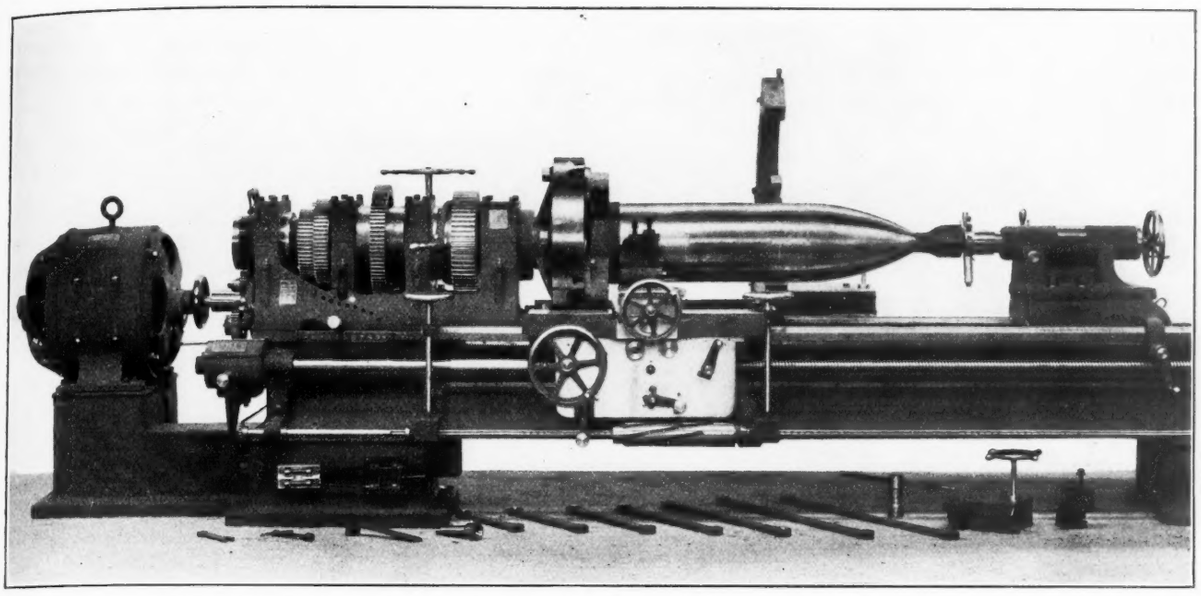


Fig. 1. Front View of Lathe showing Device beneath Carriage for Automatically Regulating Speed to Diameter.

LODGE & SHIPLEY PROJECTILE LATHE.

The three half-tones herewith are illustrations of a new lathe recently brought out by the Lodge & Shipley Machine Tool Co., Cincinnati, O., which was built for them by a prominent projectile manufacturing concern. It is motor-driven, the motor used being a Ridgway 15 H. P., with speeds of 350 to 1,750. The controller has 20 speeds, and is operated from the carriage, or at the headstock. The ratio of back gearing in the head is 1.62 : 1 and 2.62 : 1; the ratio of the motor shaft to the live spindle is 7.48 : 1 and 15.1 : 1. All gearing in the head, that is, the main driving gears, has cast iron centers, with machinery steel rims of extra width. The sizes of the spindle bearings are: Front, 7⅞ inches diameter by 8¾ inches; back, 7½ by 5⅝ inches. The spindle is of crucible steel .55 carbon; the hole through the spindle is 2⅜ inches diameter. The lathe is designed at minimum speed of motor, to have a cutting speed for roughing on the body of the shell of 30 feet per minute, and for finishing of 60 feet per minute. It will be seen that the milled cylinder on the speed control shaft, immediately under the apron, provides an automatic mechanical and full electrical speed variation for varying diameters, so that the cutting speed may be continuous from 2 inches diameter up to the largest diameter.

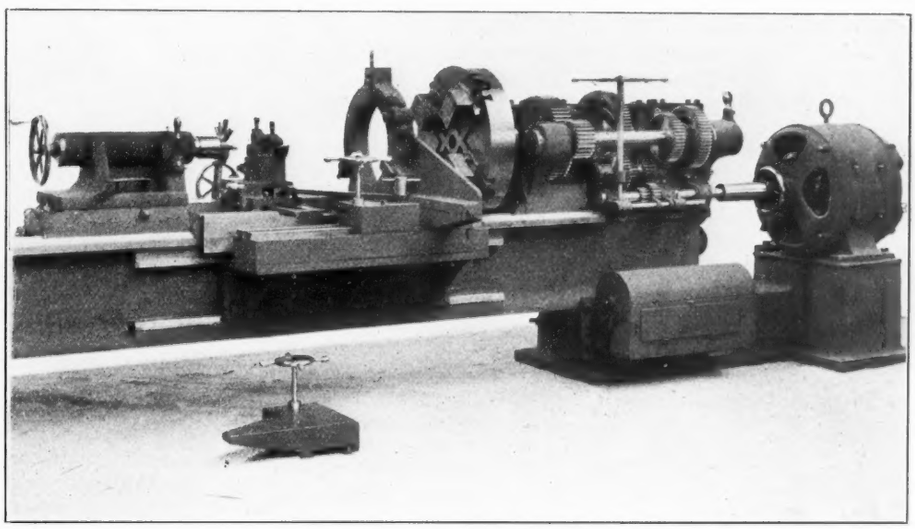


Fig. 2. Rear View showing Radius Bar for forming Points.

The tool post is of steel. There is a special steady rest, which is quickly applied and removed, also the radial attachments for furnishing several desired curves. The chuck was made in the company's shop, and is of massive and substantial design. The diameter gages shown on the nose of the tailstock are great economizers of time.

The lathe here illustrated is of 27-inch swing and has a 14-foot bed, but the length of bed can be varied to suit requirements.

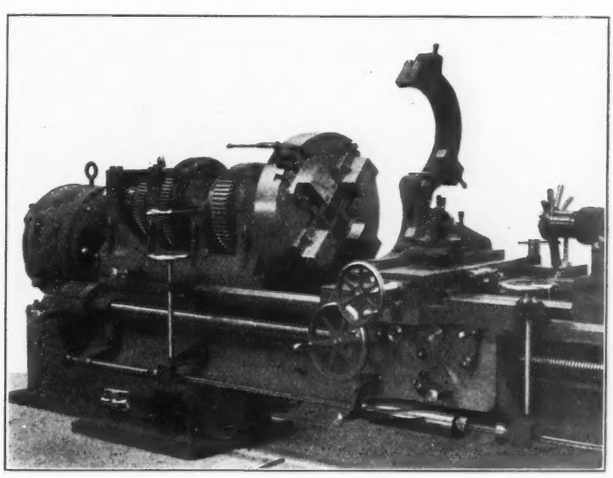


Fig. 3. Showing Massive Chuck and Special Steady Rest.

MECHANICAL DRAFT APPARATUS.

The application of fans to induced draft work has made necessary many changes from the established standards of fan builders in order to avoid difficulties never met with in other lines of their work. Most fans are built with two or three spiders, and a comparatively short distance between the bearings. With this arrangement there is no deflection of the shaft and the fan wheel runs very smoothly, but when these fans have to be adapted to the handling of hot gases, the bearings must be removed from the path in which the

Fig. 1. Improved Fan Wheel Construction.

gases travel, as they become overheated. This necessitates either having an overhung wheel, or placing one bearing outside the inlet chamber built on the side of the fan. Unless the bearings are placed very close to the center of the fan, the overhanging will cause deflection which will work the keys loose and also cause the fan wheel to strike the housing, while the same is true of the two bearings far apart. Increasing the diameter of the shaft is not a relief, as it will deflect by its own weight. Again, the intense heat within the housing causes it to expand, and as the steel framework outside the shell is at a much lower temperature, the natural curvature is inward. Fig. 1 shows a wheel made by the American Blower Co., Detroit, Mich., with a view to overcoming these defects. The spider is made of "L" beams, which have

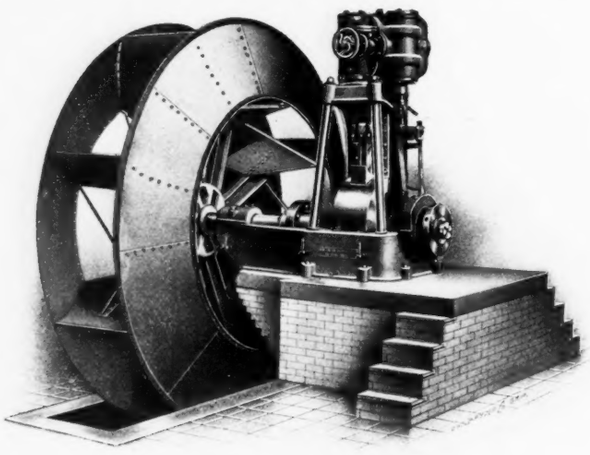
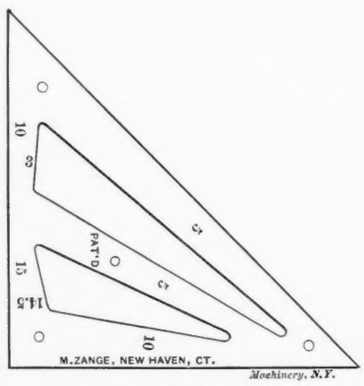


Fig. 2. Direct-connected Engine and Fan.

about three times the strength of a double set of tee arms as usually employed, and every blade is braced with bar iron braces from the outer rim to the center, thus overcoming any tendency to twisting. A very deep cone, reaching in close to the hub, is built in the side of the fan housing, while a special arm of heavy construction is built on the cantilever principle to carry the water-jacketed inner bearing, and placed at the apex of the cone. The distance from the end of the apex to the end of the projecting shaft seldom exceeds a foot. Fig. 2 shows a fan wheel mounted on a shaft with a direct coupled engine, though it is not always customary to make an extension of the base of the engine as here shown. In some cases an I-beam grillage is built into the brick foundation, the engine being set on the top of the outer ends of these beams and anchored down, and this makes practically a complete unit of the entire outfit.

IMPROVED TRIANGLE.

The illustration herewith shows a triangle made and sold by Max C. Zange, 417 Washington Avenue, New Haven, Conn. Besides the usual 90- and 45-degree angles there are two triangular spaces cut out of the triangle, the sides of which make definite angles, as indicated in the illustration. The angle between the two long sides of the lower triangle is 15 degrees, and between the sides of the upper triangle, 10 degrees. Starting at the bottom, the edge of the lower triangle makes 10 degrees with the base; and the upper edge, 25 degrees with the base. The lower edge of the upper triangle makes 30 degrees with the base, and the upper edge, 40 degrees. Turning the triangle around 90 degrees the short edge



Improved Triangle.

of the right-hand opening makes 14½ degrees with the base—an angle useful when drawing 29-degree threads on teeth. The short edge of the other opening makes 3 degrees with the base. Three small circular holes are ⅜, 5-16 and ¼ inch in diameter and are to be used in section lining, thus: Draw a section line on the 45-degree edge; put a pencil point down to the paper against one side of one of the holes and slide the triangle along the T-square till the other edge of the hole strikes the pencil; then make another line, and so on.

The triangle is provided with a small handle at the center which slides through, so that it may be used either side up and will rest flat on the paper.

STURTEVANT ENGINE.

The B. F. Sturtevant Co., Boston, Mass., have brought out a generating set consisting of a high-speed horizontal engine, direct connected to an electric generator, both of their own manufacture, and having a number of new features.

The reciprocating parts of the engine are counterbalanced with disks loaded with lead shrunk on to the crankshaft, which is a solid forging. All the main bearings are babbitted. The frame of the engine has a water sheet partition, which prevents water from the piston rod stuffing box from reaching the interior of the engine frame, and the oil on the reciprocating parts from being thrown out into the engine room. The frame is enclosed on both sides by removable plates, and the crank webs are enclosed by a cast iron hood, having two removable covers, one for the purpose of cleaning the crankpin box while it is in motion, and the other for removing the box without taking off the entire hood.

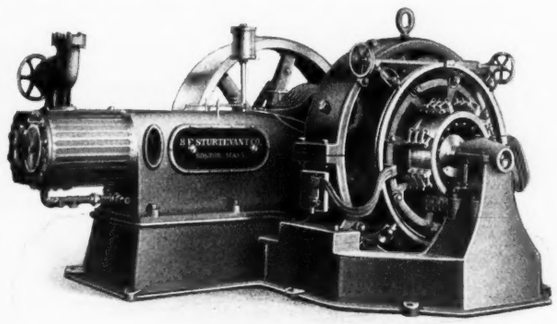
Provision is made for oiling either by the gravity or the forced pump system. In the former system, at each point where the oil is delivered are a glass gage and valve for regulating the flow at that point. With the pump, or forced lubrication system, a pump is located in the base of the engine and is operated by the crankshaft. Oil is delivered from this pump to the main bearings and from the main bearings through holes in the crankshaft and web to the crankpin. From this point the oil is conducted up through a hole in the connecting rod to the crosshead pin. A separate set of

pipes conveys the oil from the crosshead guides to the valve stem guides. The pressure of oil in the bearings under this system will vary from 12 to 13 pounds per square inch. The mechanical efficiency of the engine is so materially increased by this system of lubrication that its demand is rapidly increasing.

The engine is governed by a Rite's governor, giving very close regulation, and by adopting a modification of the Marshall valve gear an adjustment of the cut-off from zero to 70 per cent is attained.

The generator of this set is of the eight-pole type, capable of carrying momentary overloads of 50 per cent without any shifting of brushes or flashing of the commutator and an overload of 25 per cent for a period of two hours without undue heating. Before being shipped, the generator is given a breakdown test of 1,500 volts, alternating for sixty seconds between the conductors and the frame of the machine, to test the insulation.

The magnet frame is of high-grade cast iron, split horizontally. The pole pieces are of wrought iron with cast iron shoes or horns, and are secured to the magnet frame by through bolts. Any of the pole pieces may thus be removed to repair the field coils. The latter are wound up in two sections, with an air space between the shunt and series coils. The shunt winding is of double cotton-covered magnet wire with waterproof insulation. The series winding is of solid copper bars insulated in the same manner as the shunt coil.



Sturtevant Engine and Generator.

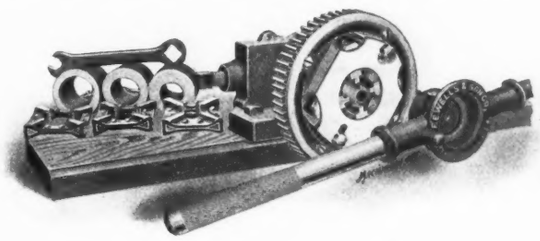
The armature is of the ironclad, form-wound, ventilated drum type, having a core built up of charcoal iron plates, japanned, mounted upon a cast-iron spider, and held by end flanges. The armature conductors are of copper bars.

In the construction of the commutator only drop-forged or drawn segments are used, these being secured in cast iron shells of spider construction and clamped in place with a steel ring. No cast segments are used. The brushes are of carbon and so proportioned as to allow at least one square inch of brush area to every 30 amperes carried. The brushes are held in holders so arranged that the entire set of brushes may be rotated completely around the commutator. Hand wheels are furnished for adjusting the brushes in position.

"WELLS" PIPE THREADING MACHINE.

The pipe threading machine illustrated herewith, for threading 1- to 2-inch pipe, is the product of the F. E. Wells & Son Co., 22 Riddell St., Greenfield, Mass. It is a very simple and compact little machine weighing about 45 pounds. It is used much like a hand diestock but it has gears to multiply the power, so that one man with this device can easily thread pipe that usually requires two with a hand stock.

The die is held in the large gear, which has a threaded shank screwing into the main frame and acting as a leadscrew to start dies. The pipe is centered by means of bushings, as in an ordinary die stock, and is prevented from turning by two vise jaws on the back of the machine operated by setscrews. All the gears are machine-cut, and the castings are of malleable iron, to save weight and yet have ample strength for the hardest usage. It can be bolted either to a bench or post, and the vise, which is a part of the machine, can be used in place of an ordinary pipe vise. With this machine the manufacturers furnish the "Economy" dies, made by them, but state that

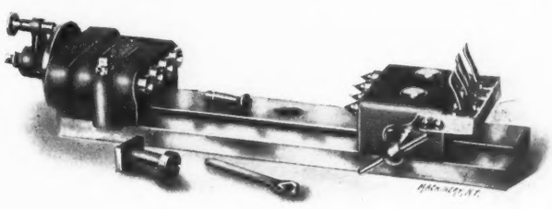


Hand Pipe Threading Machine.

any standard solid square pipe die will fit. They further state that the moderate weight and small amount of work permit its being sold at a low price.

FOUR-SPINDLE INDEX CENTERS WITH COLLETS.

The Garvin Machine Co., New York, have brought out a new line of multiple centers to supersede their style of centers illustrated in MACHINERY, April, 1903. For various manufacturing operations on small pieces, such at fluting, splining, flattening or squaring ends, etc., multiple centers are a valuable means of increasing production, as a number of pieces can be operated on in the same time and with the same attendance that would be required for one piece. The four-spindle center, with collet chucks, shown herewith, is for this purpose. The headstock spindles are hollow, so that work can be passed clear through, and are fitted with standard watch-lathe col-



Multiple Index Centers.

lets, operated from the rear. The index dial is fixed and the spindles are indexed simultaneously by one handle. In tightening the collets, all strain is taken off the dial and pointer by locking the spindles by the binder bolt on the side. The tail-block is adjustable along the base and each spindle has an independent movement forward by a spring and is thrown back by a separate handle. The spindles are bound simultaneously by one handle. The center distance of spindles is 1¼-inch. A larger size, 2-inch centers, is also made.

NEW TOOLS OF THE THREE RIVERS TOOL CO.

The Three Rivers Tool Co., Three Rivers, Mich., have brought out several new tools for boring and drilling. One of these is the Matthews core drill, shown in Fig. 1, with blades of high-speed steel brazed into the body of soft steel. This is a modification of the Matthews reamer, described in our issue of July, 1904, but is designed for the removal of a large quantity of metal from the inside of a hole, such as a cored hole, and for this reason has deeper blades than reamers and is ground with a blunt cutting angle to prevent digging into the work, and with large grooves for chips.

This drill is made in different sizes to adapt it for the various classes of work to be done with such a tool. Since these drills are primarily for removing metal, and are followed by a reamer, they are made with a small number of flutes, so that it is possible to grind them on an ordinary grinder until entirely used up. The composite construction of the drill gives all the advantages of high-speed steel at much less expense.

Core drills of this form have been used by the makers for many years, though of carbon steel, and it is found that the high-speed steel blades will render from five to six times the service of the others and at increased speed.

Another tool is a boring bar, such as has been designed and used by the Lodge & Shipley Co., Cincinnati, and shown in Fig. 3. In the description sent us the writer very pertinently calls attention to the annoyances caused by the ordinary form of boring bar and double-end cutter. Who has not had his patience sorely tried by the slot being crooked in the bar, the cutter not having a proper bearing, or, perhaps, by one of the little points used to center the cutter in the bar being broken off, or the failure of the key to fit properly? This bar has the following features, designed to overcome the usual objections:

The slot is finished complete in the machine and is central and square with the bar. The cutter has the back edge rounded to fit the slot and takes a true bearing against it. The thrust of the cut is taken against the solid metal of the bar, instead of against a key. The cutter is held to its bearing by a *transverse* key and thus avoids springing the bar; both key and slot are finished in the milling machine and the bearing in the bar is rounded like the back edge of the cutter. The transverse key serves also to center the cutter in the bar. The cutter may be sharpened until it is entirely used up without in any way affecting the centering of it, or its bearing in the bar. These cutters have been reduced to standard sizes for different diameters of bars, and may be ordered with the assurance that they will interchange. They are made of best high-speed steel.

Fig. 1. New Core Drill.

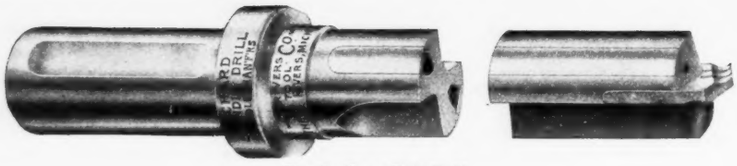
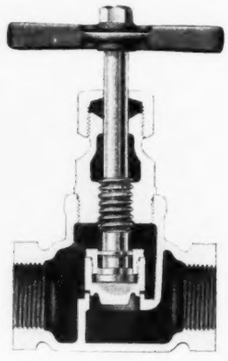


Fig. 2. Deep Hole Drill.



Globe Valve of the Hancock Inspirator Company.

Fig. 2 shows a tool, the outgrowth of the experience of N. D. Chard, superintendent of Lodge & Shipley Co., and used by them in drilling holes in their lathe spindles. This is being manufactured by the Three Rivers Co. It is a straight-grooved two-lip drill, provided with channels for conducting the oil or drilling compound to the point of the drill, to keep it cool and to wash out the chips. The body of the tool is of hard steel, being of unannealed tool steel in the longer lengths, to give greater stiffness. One advantage is the high-speed steel removable point, which may be changed when dull by simply knocking out a taper pin. These points are inexpensive, and the manufacturers of the drill make a small fixture for use in sharpening them. As an instance of what these drills will do, it is stated that the Lodge & Shipley Co. are drilling 1¼ inch holes in 22 spindles of 50-point carbon steel in ten hours. These spindles are 28 inches long, which makes an average of over one inch per minute for an all day's run.

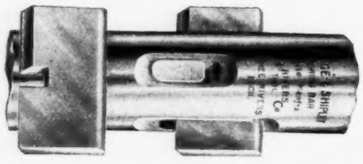


Fig. 3. Boring Bar.

NEW GLOBE VALVE.

A new globe valve has been brought out by the Hancock Inspirator Co., 85-89 Liberty Street, New York, in sizes up to three inches. They are of a special composition, giving great strength and resistance to wear, and are made of the same proportions for all pressures to 4,000 pounds per square inch, and are tight under a water pressure of more than 1,000 pounds per square inch; and for 500 pounds steam pressure. The valve disks are of a special mixture not containing zinc, and the spindles are of Tobin bronze, working in a special composition bonnet, which experience has shown will not cut under high steam pressures. In this respect the experience gained in the manufacture of injectors has been made use of. Attention is called to the way in which the valve is guided upon the stem by two collars, thereby compelling the disk to sit squarely. The valve seat is flat and the valve disk has a projection on it which serves two purposes: It acts as a guiding ring when the seat is ground and prevents cutting of the seat by the wire-drawing of the steam when the valve is slightly opened. Also, as this projection is tapered slightly it allows the steam to blow out and clean the valve seat when the valve is opened.

The bonnet is made with a long thread and a narrow shoulder, by which means it is found easier to maintain a tight joint. A T-handle is employed and fits on the tapered end of the spindle, which has one side flattened to fit a taper hole of corresponding shape in the handle. There is thus no trouble from the handle working loose. When it is necessary to regrind the valve the bonnet is removed, the disk nut unscrewed and a piece of wood inserted in the disk, enabling it to be ground perfectly, as the projection on the disk guides it and no special regrinding tools are necessary.

DEVICE FOR TRUING COMMUTATORS.

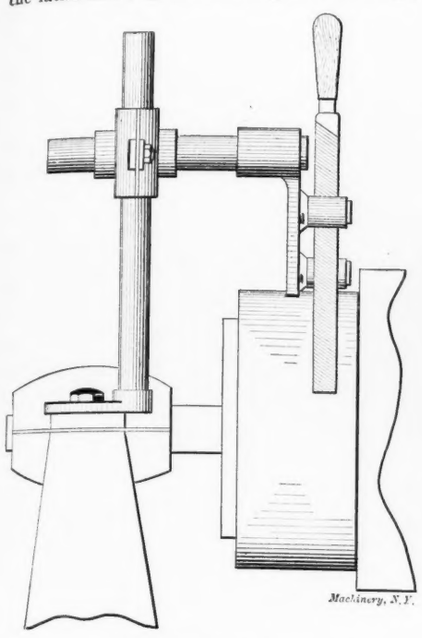
A device for truing commutators by filing has been brought out by the Excelsior Machine Works, Akron, O. The simple construction and method of attaching this device to the generator are clearly shown by cut on next page. One of its principal advantages is that no particular skill nor previous experience in truing commutators is required in order to insure satisfactory results, while the device is applicable to generators of all sizes.

The principal part is the standard, which is provided with a suitable foot by means of which it is securely attached to the generator by one of the cap bolts on the bearing. A horizontal bar is clamped at any height desired. This carries a file holder, which is moved along on the horizontal bar to meet the requirements of the commutator surface. The cutting tool is an ordinary file held in the proper position by means of the file holder. The pins, or file rests, one of which is slotted, are so located as to steady the file without the possibility of chattering.

The file, it will be seen, is moved back and forth over the commutator, and, being rigidly secured, similar to the cuttting tool in the ordinary toolpost, it cuts to a uniform depth, thus not only leveling the surface lengthwise, but restoring the true cylindrical form. Another feature is that commutators may readily be smoothed off as soon as the surface shows the first signs of becoming rough, and before it has become sufficiently uneven to warrant the removal of the armature or even the amount of metal that would ordinarily be taken off by means of a cutting tool. These little machines are manufactured at a low price.

HOLLOW HEXAGON TURRET LATHE.

The No. 3 hollow hexagon turret lathe illustrated herewith has been designed and constructed for the use of high-speed tool steels. It is made in three sizes by the Warner & Swasey Co., Cleveland, O. Fig. 1 shows a general view of the lathe and Fig. 2 an enlarged view of the turret and of the feed in either direction, varying from 20 to 100 (revolutions of spindle to feed one inch), and screw-cutting feeds for leading-on dies are also provided. The feed rack is located on the top of the bed, midway between the vees, as high up as possible, thus obviating the torsional strain in usual construction, where the rack is placed at the side of the bed. Power



Commutator Truing Device.

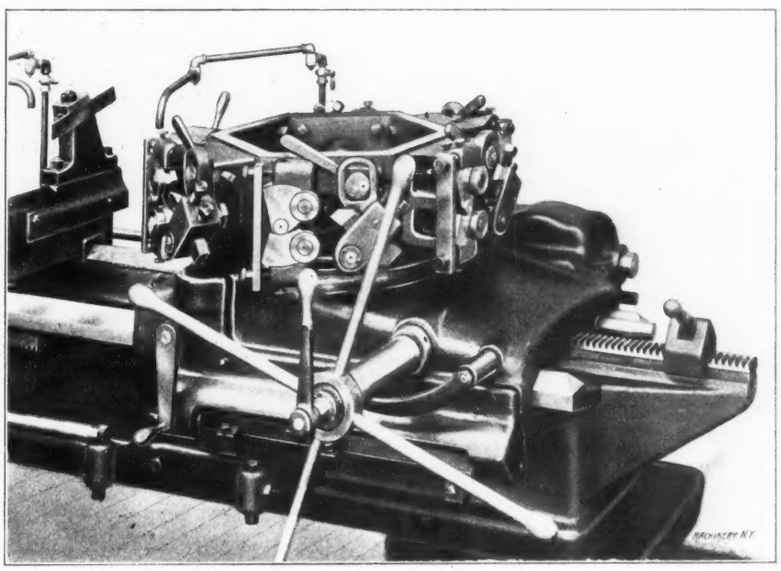


Fig. 2. Showing Turret and Tools of Hollow Hexagon Lathe.

universal turners. The head and the bed of this machine are cast in one piece. The bed is very wide and deep and the vees large.

The cone is geared 3½ to 1 and back-geared 13 to 1, the back gears being engaged and disengaged by friction clutches. There are twelve spindle speeds, ranging from 18 to 190, in geometrical progression, giving about 100 feet surface speed on diameters from 2 inches to 3⅝ inches.

The automatic chuck and the power roller feed, handle bar stock of any shape. The chuck is held in the head of the spindle, which is forged solid, thus bringing the chuck jaws close up to the front spindle bearing, with a minimum of overhang. The chuck is operated by the long lever in front of the head, working through a system of compound levers, which quick traverse in either direction is provided for the rapid handling of the turret, and for indexing, the movements being controlled by the lever in front of the turnstile. The independent adjustable stops for each face of the turret are located in front of the saddle, where they are easy of access for changing and adjusting, and at the same time are well protected from chips and dirt.

The hollow hexagon turret is 18 inches across flats, and has a broad bearing on the carriage. It revolves on and is kept central by a large taper bearing with ample provision for taking up wear, and its trussed form provides an exceptionally rigid support for the tools. The index is nearly the full diameter of the turret, and the lock bolt is placed directly under the working tool.

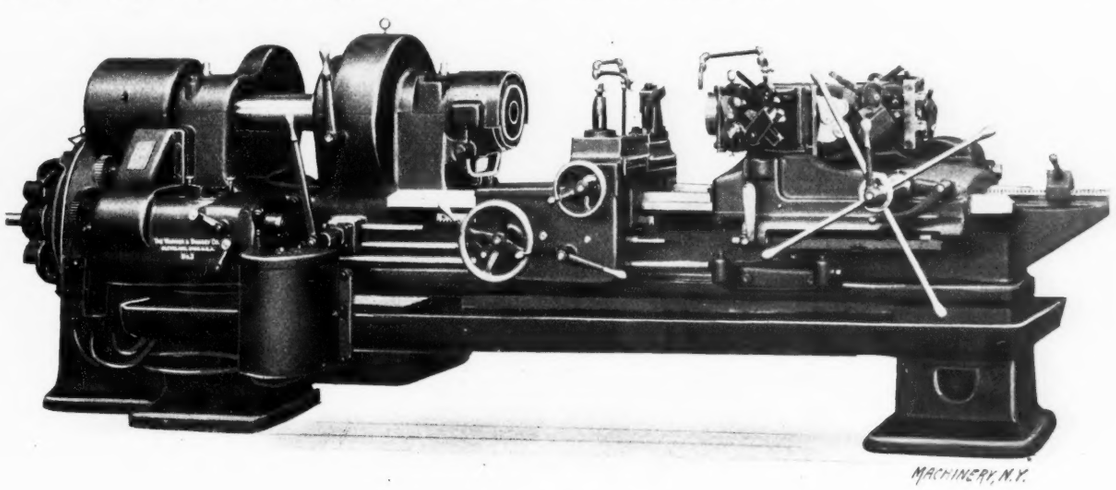


Fig. 1. Heavy Hollow Hexagon Lathe.

give a powerful movement for closing the jaws. The jaws are quickly changed for different diameters of stock and a single screw adjusts the roller feed and the guide fingers.

The turret saddle slides directly on the bed, eliminating all overhang. It is gibbed to the outer edge of the bed by flat gibs throughout its entire length. There are four changes of

The tool equipment is adapted for a great variety of work, including thread-cutting. The universal turners are adapted for using high-speed tool steels, one of the special features of the tool being the roller back rest, which eliminates the excessive friction due to high speeds. The holder which carries the cutting tool swings about a stud, and can be accurately ad-

justed by means of a screw, while an eccentric lever provides means for quickly withdrawing the tool from the work.

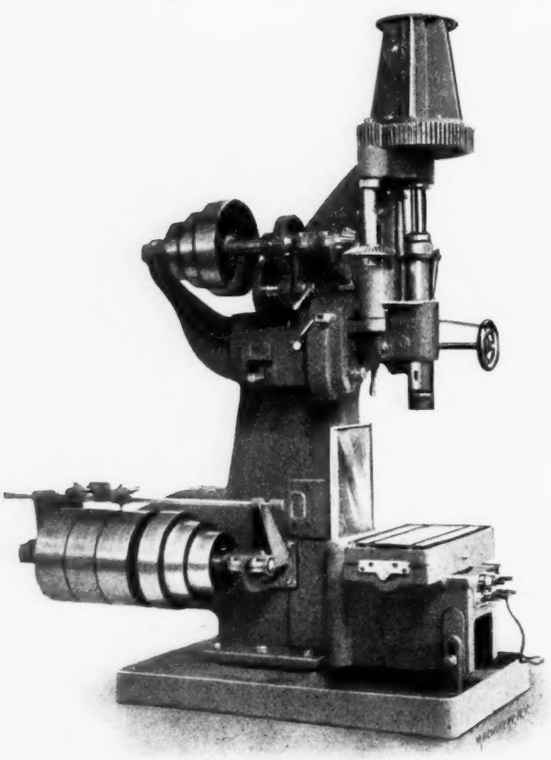
The carriage has 30 inches traverse longitudinally and 10 inches cross motion, both with four changes of feed in either direction. The longitudinal feeds vary from 24 to 120 and the cross feeds from 62 to 312 (revolutions of the spindle to feed one inch). Both feeds have adjustable automatic trips. There are two stops, with automatic trips, for the longitudinal travel; and the cross-feed screw is fitted with a graduated dial. The front of the cross-slide is equipped with a suitable toolpost for holding forming and turning tools, while the rear end carries a holder for cutting-off blades.

All the feeds are gear-driven, and are quickly and easily changed by simply shifting a lever in the feed box. The turret and carriage feeds are independent of each other. The pan and oil reservoir are large. A geared oil pump, operating in either direction, delivers a copious flow of oil to the cutting tools for both the turret and carriage, through two systems of piping. Gears and other revolving parts are covered by metal guards.

The machine shown in the photograph is electrically-driven by a variable-speed motor, direct-connected to the back gear shaft. For belt drive the spindle is equipped with a three-grade cone, and a triple friction countershaft. The net weight of this tool is about 12,000 pounds.

CYLINDER BORING MACHINE.

The half-tone herewith illustrates a new cylinder boring machine just placed on the market by Baker Bros., Toledo, O. The manufacturers call special attention to the time required to bore with this drill and give as an example a closed-end cylinder of 4⅝-inch bore, 11 inches long, upon which the time



Cylinder Boring Machine.

for the roughing cut was 7½ minutes; for the second cut, 11 minutes and for reaming 3½ minutes, making the total time for the three cuts 22 minutes.

This machine is fitted with a compound table having 10 inches in and out adjustment, and 24 inches cross adjustment. The table screws are fitted with micrometers so that multiple cylinders may be accurately spaced. A gang of four of these machines has the advantages of a four-spindle machine and these machines have the same efficiency when boring out one-, two-, or three-cylinder engines that they have on four-cylinder engines. The time given above is for multiple cylinder engines where the bore must not only be perfectly true to size, but parallel besides. With independent cylinders, or with open-end cylinders, where a lower support for the boring bar is used, the time may be materially decreased.

Six changes of speed can be obtained and the machine is provided with positive geared feed, giving a range of feeds from ⅛ inch to .004 inch per revolution of spindle. It is also provided with open and cross belts and hand reverse for tapping, and with oil pump, piping and tank for receiving the surplus oil. There is an automatic stop, for stopping the feed when the spindle has reached the required depth, and all handles for operating the tables are in front, easily accessible for the operator. The main specifications of this tool are: Maximum swing, 23½ inches; diameter of spindle, 2¾ inches; vertical traverse of spindle, 4¼ inches; longitudinal movement of table, 24 inches; transverse movement, 10 inches; vertical movement, 24 inches.

NEW HENDEY-NORTON LATHE.

A lathe with special features in the way of improvements for increasing the production is illustrated herewith. It is the product of the Hendey Machine Co., Torrington, Conn.

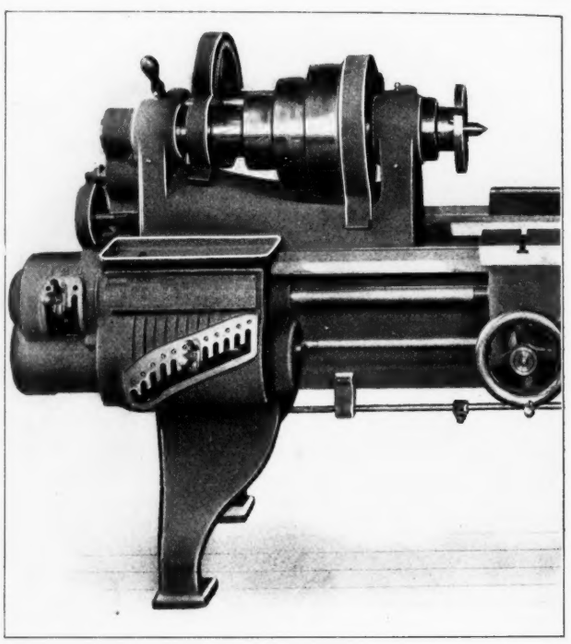


Fig. 1. Headstock End of New Lathe.

Attention is called to the new compound gear box which is applied to all sizes of this lathe, from 12-inch to 20-inch swing. This combination gives a broad range of threads and feeds, approximating threads from 1½ to 80 per inch and

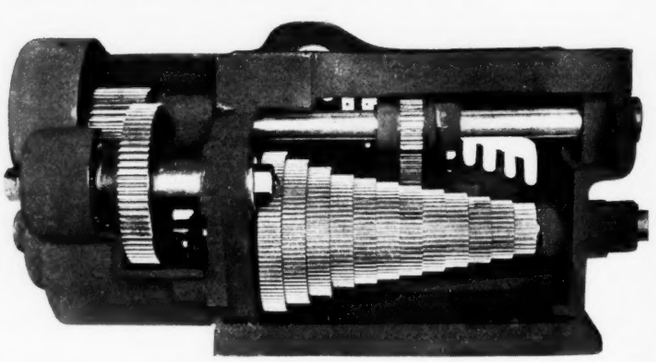


Fig. 2. Rear View of Feed Cone.

feeds from 7½ to 400 per inch. The threads available in this range are all standard pitches. Outside of this regular list of threads, the gearing on the sector of the lathe is so ar-

ranged as to be easily changed so that any special thread or threads not found on the index may be cut with special gear, which gear also works through the whole 36 combination, often cutting other useful threads.

The Hendey-Norton lathe head includes the taper bearing, self-oiling form of spindle construction with annular form of bearings carried in housings having large oil pockets in which a ring oiler for the bearing is suspended, furnishing constant lubrication to the bearings while in motion. The ample lubrication, and the rigidity of the bearings

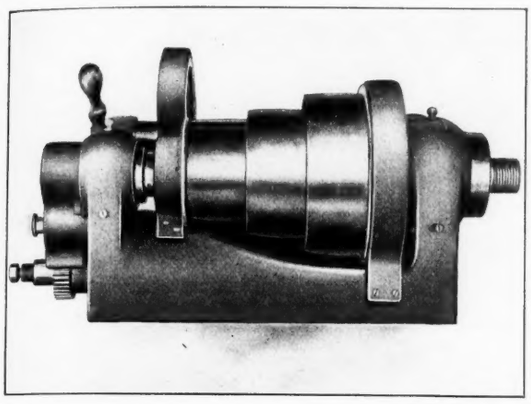


Fig. 3. Headstock Fitted with Three-step Cone for Wide Belt.

make these lathe heads long-lived in alignment and wear. The company state that an inspection and tests made of this lathe head with this form of bearing after six years' continuous service in their shops showed practically as good a bearing as when first assembled, and the alignment of the spindle was maintained with no perceptible change from the beginning.

The strength and rigidity of this lathe head make it possible to use three-step cones in place of the four-step at any time when it is desired to get more power in the spindle drive for high-speed steel work. It is to be noted that as all Hendey-Norton lathes run both belts from the countershaft in the cutting direction, the two countershaft speeds in connection with the three-step cones give 12 different spindle speeds, two more than are obtained with the ordinary type of lathe carrying five-step cones.

The addition of steel gearing wherever necessary, beds and parts made heavier than formerly, increased diameters of spindle noses for heavy chuck work, coupled with the improved features as mentioned, including the automatic stop and apron reverse for carriage, make this tool well adapted to all-around machine work as well as for tool room work.

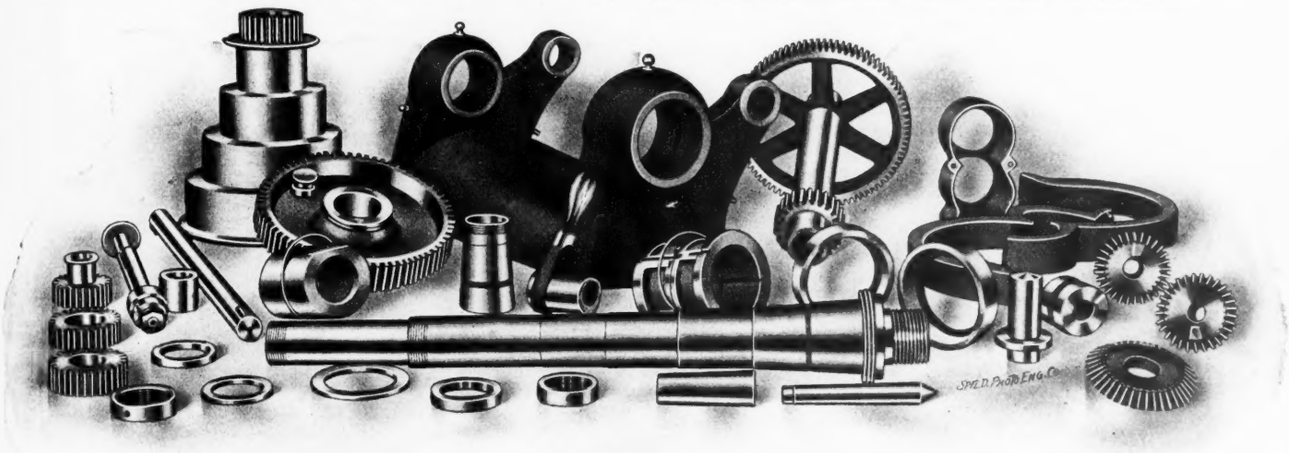


Fig. 4. View of Unassembled Lathe Head, showing the Various Parts.

* * *

FRESH FROM THE PRESS.

THE LAYOUT OF CORLISS VALVE GEARS. By Sanford A. Moss. Published in the Science Series by the D. Van Nostrand Co., New York. Price, 50 cents.

The basis of this little monograph is a series of articles upon the lay-out of Corliss valve gears contributed by Mr. Moss to the "American Machinist." It is intended as a manual for the drafting room and a complete discussion is given of the theoretical principles underlying the principles of the Corliss gear. This is followed by explicit directions for laying down the motions of a drawing board without resorting to rule-of-thumb methods. Both the single and double eccentric type of engines are taken up, although a complete economic theory of the latter type is not included.

LOGARITHMS FOR BEGINNERS. By Pickworth. For sale by D. Van Nostrand Co., New York. 47 pages. Price, 50 cents.

The purpose of this little book is to give a more detailed and practical explanation of logarithms and their various applications than is to be found in textbooks on algebra and trigonometry. The book is written in the clear and accurate style that has always characterized the work of Mr. Pickworth, and is to be recommended without hesitation to any one desiring to become proficient in the use of logarithms. A great many examples are worked out, both in the use of logarithms and of anti-logarithms, and there is also a discussion of logarithms having bases other than 10. It includes the treatment of hydraulic logarithms. The logarithmic tables contained in the book are quite brief and suited only to the working out of practice examples. The learner will need to have more complete tables of logarithms at his disposal.

SMOKE PREVENTION AND FUEL ECONOMY. By W. H. Booth and John B. Kershaw. Published by the Norman W. Henley Pub. Co., New York. 194 pages. Illustrated. Price, $2.50.

Mr. Booth, the well-known consulting engineer in England, has been a frequent and valued contributor to American technical journals, and his articles have been of such a character as to command the respect and attention of mechanical engineers generally. It is fair to presume, therefore, that this book will meet with just as much favor on the part of those interested in the subject of smoke prevention. The object in preparing the book was to bring before the fuel-using public a brief statement of the principles of fuel combustion, and of means for securing either complete combustion or smoke consumption, as the case may be. The book starts with the translation of the German work upon the subject by Ernst Schmatolla, and to this has been added considerable matter pertaining to both English and American practice. The treatise is brief and elementary, but apparently is comprehensive and explains methods for the examination of waste gases.

ELECTRIC FURNACES AND THEIR INDUSTRIAL APPLICATIONS. By J. Wright. Published by the Norman W. Henley Pub. Co., 132 Nassau Street, New York. 288 8-vo. pages. Illustrated. Price, $3.00.

The electric furnace is a comparatively new development in the industrial world and the magnitude of the industries that have come into existence through its use, at points like Niagara Falls where immense water powers are available, makes a study of such furnaces both desirable and necessary to those in any way connected with the manufacture of electro-chemical products. The following chapter titles will indicate the scope of the work: Arc Furnaces; Resistance Furnaces and Typical Processes; Calcium Carbide Manufacture; Iron and Steel Production in the Electric Furnace; Phosphorus Manufacture in the Electric Furnace; Glass Manufacture in the Electric Furnace; Electrolytic Furnaces and Processes; Miscellaneous Electric Furnaces and Processes; Laboratory Furnaces and Experimental Research; Tube Furnaces; Terminal Connections and Electrodes. Efficiency and Theoretical Considerations; Measurement of Furnace Temperatures.

STEAM BOILERS, THEIR THEORY AND DESIGN. By H. DeB. Parsons, B.S. and M.E. Published by Longmans, Green & Co., New York. 375 8vo pages. Illustrated. Price, $4.00 net. By mail, $4.50.

Mr. Parsons is engaged in the work of consulting engineer, and delivers a course of lectures each year at the Rensselaer Polytechnic Institute upon steam boilers. This book covers the subject matter of the lectures and is intended to cover such points as in practical office work may be found to be perplexing. The book is largely descriptive, such mathematics as are used being extremely simple, and it treats of the subjects of combustion, fuels, boiler settings, chimneys, boiler auxiliaries, mechanical stokers, smoke prevention and superheaters, besides the treatment of the boiler itself and the materials entering into it. The illustrations are all made especially for this work and are unusually clear. They number over 150. The book is to be recommended to anyone desiring a complete but elementary treatise on the steam boiler. We are inclined to think it contains practically all the information that even the designing engineer would need to have at his disposal.

DIMENSIONS OF PIPE, FITTINGS AND VALVES. By W. D. Browning. Published by the Draftsman Co., Cleveland, O. 82 8-vo. pages. Illustrated. Price, 75 cents.

This little book is one of the most useful compilations of data for draftsmen that we have seen. It gives exactly the information that any one having to lay out piping would wish to have at his disposal. It is a compilation of tables on iron, lead and spiral-riveted pipe, cast-iron pipe, drain pipe, etc. These tables include dimensions and particulars in regard to the pipe itself, to their fittings, valves and

miscellaneous articles that go into pipe work. Not only the usual tables to be found in engineers' handbooks and catalogues of pipe manufacturers are here given but also dimensions such as draftsmen need, like for example, the principal dimensions of valves, elbows, tees and other fittings; boiler fittings, such as water columns, gages, injectors, etc.; also particulars in regard to laying out piping for steam-heating bath rooms, etc. It would be highly desirable to have more books of this sort upon other subjects, containing similar data for ready reference.

ELEMENTS OF MECHANICAL DRAWING. By Alpha Pierce Jamison, M.E. Published by John Wiley & Sons, New York. 226 8vo. pages. Illustrated. Price, $2.50.

This book has been developed at Purdue University for instructing first-year students in technical schools, and embraces those branches necessary to give the student such knowledge as will prepare him to pursue a course in engineering. It appears as though at this late day students in drawing would have no difficulty in securing textbooks adapted to their needs. This is a well-written and carefully illustrated volume which becomes another addition to the many excellent treatises on drawing. The illustrations are unusually good and the subject matter is grouped under the following headings: Elementary Principles and Definitions; Letters, Figures and Lettering; Projection; Drawing Tools and Materials; Reproduction of Drawings; Patent Office Drawings; Gearing; Color Work; Sketching; The Mechanical Execution of Drawings. The chapter on lettering offers good suggestions; the one on projection is rather brief in its treatment, as is also the one on gearing. The chapter upon the mechanical execution of drawings takes up quite fully the characteristics of working drawings.

ELEMENTS OF GENERAL DRAFTING FOR MECHANICAL ENGINEERS. By C. E. Coolidge, assistant professor, and H. L. Freeman, instructor, in the mechanical department of machine design, Sibley College, Cornell University. Published by John Wiley & Sons, New York. Size, 9 x 12. 51 pages. Illustrated with 21 folding plates. Price, $2.50.

Messrs. Coolidge and Freeman have treated the subject of working drawings exclusively in this textbook, giving what we suppose to be the course of Sibley College upon this subject. As a treatise in the production of working drawings it easily stands as one of the most complete that has appeared. No attempt is made to include anything upon machine design, but rather to show by well-executed plates and suitable descriptive matter what conventional and mechanical drawing are, and how working drawings of different subjects are to be made. The plates include full details of a pillar shaper besides a number of engine parts, to show how machine details should be laid out. In addition there is a plate showing a lay-out for piping, one showing engine foundations with templet for anchor bolts, one showing a plan of a building, one in isometric projection and a patent office drawing. The book describes the selection, use and care of materials and instruments for drawing, and the student is shown how to put in a definite form a standard drafting room system which has been worked out by the authors after careful study of many systems.

ELEMENTS OF MECHANISM. By Peter Schwamb, S.B., and Allyne L. Merrill, S.B. Published by John Wiley & Sons, New York. 264 8vo pages. Illustrated. Price, $3.00.

The main subject matter of this work was written nearly twenty years ago by Prof. Schwamb, and has since been used in the form of published notes for instruction in mechanism in the Massachusetts Institute of Technology. Inasmuch as calls were made for the notes from other schools, and it was decided to revise them, they are now brought out in book form. The book, as its name implies, deals almost entirely with elementary motions entering into the mechanism of machine parts. The treatment of the various elements follows closely the plan outlined many years ago by Prof. Reuleaux, but—and this seems to us a decided advantage—these methods have not been followed to the extreme position taken by many writers on mechanism who, in the attempt to be logical, treat the subject in a way that not only would not appeal to practical men who are largely responsible for the various mechanisms treated, but that would be positively confusing to them. The subjects of centroids, instantaneous centers, etc., receive proper recognition, but the book is not filled with such terms. The subjects of cams, parallel motions, crank motions, quick return motions, escapements, trains of gearing such as found in engine lathes, clocks, cotton machinery, etc., and epicyclic gearing appear to be treated very completely. The chapter on speed cones merely takes up the mathematical calculation of the length of belts without giving any of the recent graphical methods developed for laying out such cones. While the book professes to deal only with the elements of mechanism there is a chapter entitled "Aggregate Combinations" in which are shown a few combinations of moving parts, and the book would seem more complete if there had been included in this chapter some of the recent important mechanical movements that have been developed, such for example, as the speed cone arrangements so universally employed in machine tools. Following the treatment of mechanism are about 75 pages on the subject of gearing, showing how to lay out gear teeth. This part appears to be unusually complete.

MANUFACTURERS' NOTES.

THE GRAHAM MFG. CO., Providence, R. I., report that fire recently destroyed most of their stock (over 200 vises), but that they will be able to fill orders that come.

THE JACOBSON MACHINE MFG. CO., Warren, Pa., have just completed a line of patterns for an automatic gas engine in sizes from 5 to 200 H. P., of which they will be glad to furnish full description to any one interested.

THE RAND DRILL CO., New York, report that the United States Government have just purchased from them twenty-seven "Imperial" pneumatic hammers and drills, to be used in connection with the Manila harbor improvements.

THE NORTHERN ELECTRICAL MFG. CO., Madison, Wis., report the following orders recently received: A 200-K. W. Northern generator; Northern dynamos and motors for use in brewing work; three 150-K. W. slow-speed generators, etc.

GEORGE WILLIAM HOFFMAN, Indianapolis, Ind., announces that the "U. S. Metal Polish and Bar Keeper's Friend" received the highest award at the Chicago World's Fair in 1893 and also at the Louisiana Purchase Exposition this year.

THE STANDARD ROLLER BEARING CO., Philadelphia, Pa., have just doubled the size of their plant, have been running all night almost constantly for the past two years. They have just purchased a tract 300 feet by 20 feet for another addition to their foundry.

THE HAYES FILE CO., Detroit, Mich., have just purchased all the machinery and tools of the Simonetta File Co., which was organized in Detroit last May with a capital of $25,000 to manufacture files under a secret process. The Hayes File Co. expect to catch up with their orders as soon as they get the above machinery installed.

THE MASSACHUSETTS TOOL CO., Greenfield, Mass., are offering as a special bargain, from the first of the year till March 15, 1905, four tempered steel rules (one each) 2-inch, 3-, 4- and 6-inch, for $1.00. The accuracy of these rules is guaranteed, and they will be sent to any part of the United States on receipt of the above price.

THE WATSON-STILLMAN CO., New York, announce, with regard to their recent fire, that at present some of their tools are running and that through the courtesy of some of their friends, whose shops have been thrown open to them, they have been enabled to take care of their customers promptly.

THE STOW FLEXIBLE SHAFT CO., Philadelphia, Pa., report the following recent orders: A Halsey portable drill for a firm in Vancouver; an 18-foot flexible shaft and a large crankpin turning machine; also three complete electric hammer outfits, shipped to Italy, for use in the Government navy yards.

THE GARRY IRON & STEEL CO., Cleveland, O., recently shipped ten 30-ton pneumatic jacks, a hand power jib crane and a pneumatic jib crane to three customers. Their recent orders include a 3,000-pound revolving pneumatic crane, mounted on car, and six 1-ton buckets; a 5,000-pound revolving electric locomotive crane; a 15-ton hand power pillar crane; and one 6-ton hand power overhead traveling crane.

W. S. ROGERS, Supt. Philadelphia Bourse, Philadelphia, advises us that the following concerns recently rented space and placed their products on exhibition in the Bourse Exhibition: the Murray Iron Works, engines; the N. C. Lane Co.; Collins damper, regulators, oil filters, etc.; Germania Lamp Co., electric lamps; J. H. Lake & Vaughn Bros., gas and gasoline engines and launches; E. H. Godshalk Co., gas and gasoline engines and launches; Egry Autographic Registering Co., registers and the Egry merchandise systems; Philadelphia Gear Wks. (formerly Grant Gear Wks.), system of gearing; Novelty Tool Mfg. Co., Keystone combination tools, forge, drill, etc.; Pittsburg Fuel Saving Furnace Co., grate and smoke consuming furnace; Frank B. Smith, patent pneumatic despatch apparatus.

THE CROCKER-WHEELER CO., Ampere, N. J., who have recently become licensees of Brown-Boveri & Co., Baden, Switzerland, for their alternating current apparatus, announce the sale of three 4,000 K. W. alternators to the California Gas & Electric Corporation, of San Francisco. These are to be three-phase, 13,000-volt, 25-cycle, 83 R. P. M., revolving field alternators. They are to be driven by 6,000 H. P. gas engines built by the Snow Gas Engine Co., and will be the largest alternators ever built for gas-engine service. They are to furnish power for operating all the street railways in San Francisco and vicinity. This is the first important sale made by the Crocker-Wheeler Co. since acquiring the rights to manufacture apparatus under the Brown-Boveri patents.

NEW TRADE LITERATURE.

Manufacturers and others sending catalogues for notice are requested to address them to the Editor of MACHINERY, so that they can be kept separate from catalogues sent us for other purposes.

THE F. BISSELL CO., Toledo, O. Catalogue showing electric toys, motors and novelties, copy of which will be sent on request.

E. F. HOUGHTON & CO., Philadelphia, Chicago and Detroit. New catalogue illustrating the various methods of installing the Marck steam trap, for the economical use of steam, preventing freezing of pipes, and obtaining uniform heat at a minimum pressure. Mailed free to any one writing to their Philadelphia address, 240 W. Somerset Street.

THE COATES CLIPPER MFG. CO., Worcester, Mass. Bulletin No. 18 treating of the Coates flexible transmission. Herein are illustrated the unit-link, ball-bearing flexible shaft; also housed gear breast drills; the Coates drill press, made in three sizes; a magnetic hold-on; a diesinker's engine, with Coates patent multiplier; a friction drive center grinder, etc., all using the Coates flexible transmission. Special attention is called to the Coates angle drive, which is new.

THE LUCAS MACHINE TOOL CO., Cleveland, O. Clever little pamphlet entitled "Why Does a Dog Waggle His Tail?" to which the answer is because "the dog is bigger than the tail," and the argument is put forth that raising and lowering a heavy piece of work in a boring machine is like "the tail wagging the dog," and that it is better to raise and lower the spindle; which is how it is done with the "Precision" boring, drilling and milling machine of this company.

THE CHICAGO PNEUMATIC TOOL CO., Chicago and New York. Catalogue, standard size, of pneumatic tools. Among these are listed the Boyer riveting hammers, chipping, caulking and beading hammers, piston air drills, angle gears; the "Little Giant" flue-rolling, reaming and tapping machines; the improved "Chicago" air forge; rock drills, pneumatic motors and geared hoists, special air hoists, etc., etc. The catalogue appears to be very complete and will give a good idea of the products of this company. There are a large number of illustrations.

THE GISHOLT MACHINE CO., Madison, Wis. Illustrated catalogue, 8 x 10, of boring mills. A few sizes of the general line of vertical and horizontal mills are shown. A 34-inch vertical boring mill, with plain head and with swivel head; a 42-inch vertical boring mill with two swivel heads, and one with turret head; the 52-, 60-, 64- and 72-inch vertical boring mills; a horizontal mill; the "Gisholt" turret lathe and the "Gisholt" tool grinder. Brief descriptions accompany the very fine illustrations of each of these tools. The catalogue is printed on heavy coated paper and is a most creditable piece of work.

THE DERRY-COLLARD CO., 256 Broadway, New York. "Books and Things, No. 2," a pamphlet listing technical books. These treat of machinery, electricity, civil and steam engineering, pattern and foundry work, marine work, woodworking, plumbing and heating. There are also books on drawing and a list of the new books just out. Attention is called to the "D-C Book Club," by which plan one may buy any books or papers by paying $1, $2, $3 or $5 a month. The "Book Club Folder" explains this fully and will be sent to any one interested. This company also send on approval any mechanical book costing $1 or more, which may be returned if not satisfactory.

MISCELLANEOUS.

Advertisements in this column, 25 cents a line, ten words to a line.

The money should be sent with the order.

A MEMBER of the American Society of Electrical Engineers desires to exchange monthly "transactions" with a member of the American Society of Mechanical Engineers. Address "ELECTRICAL SUBSCRIBER," care MACHINERY, 66 W. Broadway, New York.

A NEW DEPARTURE.—The Cleveland Automatic Machine Co. of Cleveland, O., appreciating the extensive demand for competent operators, have established a free employment bureau and are soliciting the name and address of all competent non-employed operators, and in securing them they hope to not only very materially assist the operator, but also assist those who may employ them.

ARE YOU SATISFIED with your present position and salary? If not, write us for plan and booklet. We have openings for managers, secretaries, advertising men, salesmen, bookkeepers, etc., paying from $1,000 to $10,000 a year. High grade exclusively. HAPGOODS (Inc.), Suite 511, 309 Broadway, New York.